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ORIGINAL ARTICLES.

I.—On a New Specimen of the Cretaceous Fish *Portheus molossus*, Cope.

By Arthur Smith Woodward, LL.D., F.R.S.

(PLATE XVIII.)

SEVERAL nearly complete skeletons of the primitive teleostean fish *Portheus molossus* are now known from the Chalk of Kansas[1]; but none is better preserved than a remarkable trunk, nearly 12 feet in total length, lately obtained for the British Museum by Mr. Charles H. Sternberg. The specimen is shown, of about $\frac{1}{24}$ of the natural size, in the accompanying Plate XVIII, where it is seen mounted with the head of another fish of the same proportions. All the bones remain embedded in the matrix exactly as they were found, and there is no restoration beyond slight repairs.

The vertebral centra in the fossil form a continuous undisturbed chain from the pectoral arch backwards, only damaged a little by crushing. The total number of dorsal vertebræ is about fifty-five, while that of the caudals is thirty-three. From the pectoral arch backwards to the caudal fin all the centra are impressed on the side by two deep longitudinal depressions, of which the upper is the larger. In a few of the anterior centra the lower lateral depression is especially small, and restricted to the hinder half. The lower face (well seen in some of the distorted anterior centra) is flattened between the two longitudinally extended pits in which the bases of the hæmal arches are fixed. The gently arched ribs are long and slender, all reaching the ventral border of the fish. Each rib is impressed by a slight longitudinal groove, and its upper end is somewhat expanded where it fits loosely in the socket of a small parapophysis. This parapophysis, which does not appear to be firmly fixed in the pit of the centrum, is much more expanded in front of the socket than behind, and is in direct contact with the adjacent parapophyses. The arrangement is well shown in a drawing by O. P. Hay,[2] in which it was originally mistaken for a neural arch. In the anterior half of the abdominal region in the fossil the neural arches are accidentally removed, but further back several are in place,

[1] A. R. Crook, *Palæontographica*, vol. xxxix, p. 109, fig. 1, 1892; H. F. Osborn, Bull. Amer. Mus. Nat. Hist., vol. xx, pp. 377–81, pl. x, 1904; C. E. McClung, Kansas Univ. Science Bull., vol. iv, p. 243, pl. xii, 1908.

[2] O. P. Hay, Zool. Bull., vol. ii, p. 47, fig. 12, 1898; corrected in Bull. Amer. Mus. Nat. Hist., vol. xix, p. 56, 1903.

and there are a few scattered examples. Like the hæmals, they are loosely inserted in pits which extend nearly the whole length of the centra. As shown also by Hay,[1] each arch consists of a pair of thin laminæ, right and left, loosely apposed in the median plane, and surmounted by a long and slender neural spine, behind which a smaller and shorter rod-like process also rises upwards. Each arch slightly overlaps or clasps that next following, but without so well-defined a facet as that represented by Hay. Above some of the neural arches there are remains of the curved free fin-supports. In the caudal region both the neural and hæmal arches are firmly fixed in the pits of the vertebral centra as far as the origin of the caudal fin. Though longitudinally extended at their base of insertion, they do not overlap or interlock, but the tail is strengthened by the sharp backward curvature and inclination of all the neural and hæmal spines. The base of each neural arch is a little triangular expansion, strengthened by a vertical lateral ridge, but not bearing any posterior process, and not in contact with the next arch of the series. The base of each hæmal arch is shaped almost like the parapophysis in the abdominal region, but the hæmal spine is directly continuous with it.[2] The hæmal arches within the caudal fin are much thickened, in close contact, and articulate with the corresponding centra in open sutures.

There are no intermuscular bones in the caudal region or below the vertebral column in the abdominal region ; but some may perhaps occur among the confused remains in the dorsal part of the abdominal region.

The left clavicle is seen from within, and exhibits the characteristic long and slender precoracoid arch crushed upon its inner face. Below it the base of the left pectoral fin appears, showing the bases of the four stout anterior rays in their natural position. The same rays of the right pectoral fin are well displayed lying over the ribs, the longest equalling in length a chain of about eighteen vertebræ. All these rays are gently arched bony rods, flattened on the outer face and marked only with a few longitudinal striations, evidently due to their structural fibres. The first, second, and fourth rays appear to be nearly complete to their distal end, where they scarcely taper and lack all traces of transverse articulations. The first ray is the stoutest and largest, with a sharply though irregularly rounded anterior border; the second ray is at least half as wide as the first ray, and its slender distal end, split by crushing, is preserved in the fossil to a greater length than the latter; the third ray, though seen on the left, is restored on the right side, but it is clear that its distal end cannot have been much expanded; the fourth ray is less stout, and shorter than the others. Behind these rays in another specimen in the British Museum (No. P. 10611) the pectoral fin is completed by three or four very short rays, which expand distally into a finely divided and articulated portion.

The pelvic fins are preserved apparently in their natural position, arising beneath about the forty-eighth vertebra. They are less than

[1] O. P. Hay, Zool. Bull., vol. ii, p. 51, figs. 15, 16, 1898.

[2] See figures by O. P. Hay, Zool. Bull., vol. ii, p. 48, figs. 13, 14, 1898 (in which the hæmal arch is described as neural, and vice versa).

half as long as the pectoral fins—a proportion very different from that observed in the restored paired fins in the specimens at New York and Lawrence (Kansas). The pelvic bones, which are well shown, are firmly articulated in the middle line at their base, and correspond in shape with those originally ascribed to *Portheus* by Cope.[1] The first fin-ray is much stouter and larger than the others, but it expands a little towards its distal end, and must have been finely divided and articulated at its extremity. The whole fin, in fact, resembles that of another specimen in the British Museum (No. P. 6326) which has already been figured.[2]

Of the median fins, the dorsal and anal are only imperfectly preserved, but the remains suggest that these fins were arranged as in *Chirocentrites*[3] and the living *Chirocentrus*, not as in the restorations at New York and Lawrence (Kansas). The anal fin clearly arises at the beginning of the caudal region, where both the fin-supports and the bases of the fin-rays are seen in nearly undisturbed series. It is uncertain, however, whether this fin extended as a low fringe backwards—it can only be noted that a few displaced short and broad fin-supports in the hinder part of the fossil may have belonged to such an extension. The dorsal fin is represented only by a few supports and imperfect rays at some distance behind the origin of the anal, and it seems probable that if it originally extended further forwards or backwards some traces would be exhibited.

The deeply forked and powerful caudal fin is already well known, and the new specimen confirms previous descriptions. There is clearly no sudden termination of the vertebral column with a urostyle as in *Chirocentrus*; but the five or six hindmost vertebræ form an upturned series, rapidly diminishing in size, as in the Elopines and other primitive teleostean fishes.

Remains of large and thin scales occur in various parts of both the abdominal and the caudal region, and their outer face often exhibits an irregular coarse tuberculation like that of the opercular bones. The rounded tubercles do not appear to be enamelled.

The new specimen of *Portheus* now described, while confirming previous descriptions in many respects, is thus of importance as showing for the first time the relative proportions of the paired fins and the probable true relationship of the dorsal and anal fins. It has already been pointed out that there are striking resemblances between *Portheus* and *Chirocentrites*, and the facts now published concerning the fins make it doubtful whether the species belonging to these two categories can any longer be referred to two distinct genera.

EXPLANATION OF PLATE XVIII.

Portheus molossus, Cope; nearly complete trunk, with the head of another individual; about $\frac{1}{24}$ nat. size. Obtained by Mr. Charles H. Sternberg from the Niobrara Chalk of Kansas, U.S.A. (Brit. Mus. No. P. 11125.)

[1] E. D. Cope, *Vert. Cret. Form.* (Rep. U.S. Geol. Surv. Territ., vol. ii, 1875), p. 192, fig. 9.

[2] A. S. Woodward, *Foss. Fishes English Chalk* (Mon. Pal. Soc., 1907), p. 101, fig. 28.

[3] J. J. Heckel, *Denkschr. k. Akad. Wiss. Wien, math.-nat. Cl.*, vol. i (1850), p. 203. See also A. S. Woodward, *Foss. Fishes English Chalk*, p. 99, fig. 25.

II.—The recent Discussion on the Origin of the Himalayas.

By R. D. Oldham, F.R.S., V.P.G.S., etc.

THE discussion on the origin of the Himalayas, started by Sir T. H. Holland's review[1] of Colonel Burrard's memoir, appears to have been led, by the concluding sentence of that review, into an unprofitable channel; for alike in the review and in the succeeding articles by Mr. Fisher[2] and Colonel Burrard[3] it seems to have been accepted that only two theories are applicable, firstly, Mr. Fisher's discussion of the theory of the disturbed tract contained in chapter x of the first and chapter xiii of the second edition of his *Physics of the Earth's Crust*, and, secondly, that developed by Colonel Burrard. Further, it is assumed that the former is dependent on the hypothesis of a fluid earth and the latter such as should follow from the hypothesis of a solid, highly heated, and cooling globe; the connexion, in either case, being so close that the acceptance of one or other hypothesis, of the constitution of the earth, necessitates the acceptance of one and the rejection of the other of the theories of the origin of the Himalayas. This, however, is not the case; Mr. Fisher's treatment of the disturbed tract, though originally a development of his theory of a fluid earth, and quite consistent with it, is equally consistent with the hypothesis of a solid earth, for it is hardly conceivable that the substance of the most solid of globes would not yield and flow under stresses of the magnitude and duration of those involved by the support of a mountain range such as the Himalayas, and, once such a flow commenced, there would be developed a system of quasi-hydrostatic support, and an isostasy caused by a species of flotation, which is all that is demanded by the general theory or by the adaptation to the particular case of the Himalayas contained in chapter xviii of the second edition of the *Manual of the Geology of India*. I, at least, have never regarded this as having any but a very remote bearing on the hypothesis of a solid or fluid condition of the interior of the earth.

On the other hand, Colonel Burrard's explanation, so far from being in accord with the hypothesis of a solid, cooling, earth, is in reality inconsistent with it, and his view, that, in such a globe, rifts would open by contraction from the surface downwards, is the reverse of what would actually take place. The conditions existing in a partially cooled solid globe are well understood; I believe they were first pointed out by Mr. Mellard Reade in 1876, but once indicated they became a truism, and may be very briefly explained. In such a globe there would be, on the outer surface, a crust, which has fully cooled and is incapable of further contraction, and in the centre a heated core, to which cooling has not penetrated; between the two lies a belt of material which is gradually losing heat and contracting in bulk. At the inner limit the contraction of this layer

[1] Sir T. H. Holland, "Origin of Himalayan Folding": Geol. Mag., 1913, p. 167.

[2] Rev. O. Fisher, "Rigidity of the Earth," Geol. Mag., 1913, p. 250; "Origin of Mountains," Geol. Mag., 1913, p. 434.

[3] Colonel S. G. Burrard, "Origin of Mountains": Geol. Mag., 1913, p. 385.

of cooling material must cause tension, as a diminution of the circumference is resisted by the uncooled central core; at the outer limit, where no further cooling takes place, the consolidated crust would be thrown into compression by the reduction in bulk of the material below, and somewhere between these two would come a zone where the radial and tangential contractions exactly balance each other, so that the material would neither be compressed nor extended.

The depth at this level of no strain beneath the surface would depend on the initial temperature of consolidation and the temperature gradient. The latter is approximately known, the former is doubtful; Mr. Mellard Reade, assuming a temperature of about 3,000° F., calculated the depth at about 1 mile; later, Mr. Fisher calculated a depth of about 0·7 mile for an initial temperature of 4,000° F., and of 2 miles for an initial temperature of 7,000° F. Of these three values for the initial temperature the lowest is the most probable, and the calculations show that any rift, which might be formed by tension in the 'sub-crust', could not reach the surface; it would originate at the level of the greatest tensional strain, which would lie at between 30 and 50 miles below the surface, and thence extend upwards and downwards, but could not reach upwards to within about a mile from the surface. These calculations never had any geological interest, beyond showing that the hypothesis of an originally highly heated, and gradually cooling, solid globe afforded no sufficient explanation of the structure of the earth's outer crust, as revealed by geological observation in the field; they have been rendered of little more than academic and historic interest by modern researches in radio-activity, which have, incidentally, provided a means by which fissures opening at the surface of the earth and penetrating downwards could be produced; for if the earth is an originally cold globe, getting gradually warmer, and expanding in bulk, by the action of radio-active material, then such fissures would naturally be formed; but in that case none of the consequences which Colonel Burrard has drawn from his rift would follow.

In all this I have not been arguing for or against a fluid or a solid earth, but against the introduction of an irrelevant issue. Whether the earth is a fluid or a solid globe seems a matter which concerns the astronomer, the physicist, or the mathematician, much more than the geologist; for all the processes which his observations demand appear to be equally compatible with either hypothesis. Nor am I arguing against Colonel Burrard's explanation as a whole; it may stand with the others as a possible hypothesis, to be tested and examined on its merits, but the tests must mostly be of a nature quite unconnected with geological observation. When, however, Colonel Burrard postulates the existence of a rift, or narrow band of subsidence, reaching 20 miles deep from the surface, we are brought face to face with a phenomenon for which we have no precedent, and before accepting it we must be satisfied, not only that it explains the geodetic facts, but that no other explanation, in closer accord with what is known of the geology of the regions, can be found.

No one can gainsay Colonel Burrard's contention that geologists must take count of the facts of geodesy, but it is equally true that

geodesists must take count of the facts of geology, and in either case a distinction must be drawn between the facts of either science and the conclusions of individual workers, and again between those direct and inevitable deductions, which have almost the value of observed facts, and the more remote inferences, which may represent only one, or a part of one, of the possible explanations. Bearing this in view I propose to review, very briefly, the facts and explanations on either side.

On the geodetic side the facts may be summarized by taking the two stations Kurseong and Jalpaiguri, 25 miles apart, the first situated on the edge of the Himalayas, the second out in the Gangetic alluvium. At Kurseong the observed deflexion of the plumb-line is 46″ to the northwards; the calculated effect of the attraction of all visible masses, after allowance is made for the effect of isostasy, should have produced a deflexion of only 23″, leaving an unexplained residual of 23″ northerly deflexion. At Jalpaiguri the observed deflexion is only 1″ to the northwards; the calculated deflexion should have been 8″ to the northwards, leaving an unexplained residual of 7″ southerly deflexion. It may be well to point out that the values, both of the observed deflexions and of the unexplained residuals, depend on the assumed dimensions of the earth. The figures quoted are deduced from the dimensions now accepted by the Great Trigonometrical Survey of India as the nearest approach which has been made to exact accuracy, but, although the acceptance of different values for the size of the earth would alter the figures, no admissible variation would make a material change in the difference between them. For instance, if the earlier values, based on the Everest spheroid, are adopted, the observed deflexions at Kurseong and Jalpaiguri become 51″ and 6″ to the north and the unexplained residuals 28″ to the north and 2″ to the south, still leaving a difference of 30″ as between the two stations, which cannot be explained by the ordinary methods of geodetic calculation, and is only to be accounted for by some local peculiarity, or departure from average conditions. The explanation offered by Colonel Burrard is a deep and narrow rift, filled with material of less density than average rock, and situated between the two stations; there can be no question that the explanation is a feasible one, so far as the mathematics are concerned,[1] for the diminished attraction caused by the replacement of denser by less dense material would cause an apparent repulsion on either side of the rift, but before accepting this as the only, or even as the probable, explanation, we must see whether another cannot be found, in better accord with the known facts of geology.

The geological facts, which are pertinent to the question under consideration, may be simply expressed. All along the southern face of the Himalayas runs a great fault, or series of parallel faults, known as the boundary fault, on the north of which lie the older rocks of the Himalayas, and on the southern the upper Tertiary

[1] It may be added that a much lesser depth than 20 miles would not satisfy the conditions.

Siwaliks of the sub-Himalayas and the alluvium of the Gangetic plain. The Siwaliks were long ago shown, by Mr. H. B. Medlicott, to have been formed from the waste of the Himalayan range, under exactly similar conditions, and by the same rivers, as the alluvial deposits of the Gangetic plain, in other words to be merely the lower, older, and marginal, deposits of the same formation, now uplifted and exposed to denudation. The throw of the boundary fault cannot be measured directly, but it is certainly great, and may reasonably be estimated at between 10,000 and 15,000 feet, say between two and three miles. It may exceed or fall short of these limits in places, but is not likely to do so to any material degree.

On its southern margin the alluvium thins out over an old land surface. Between the two margins nothing can be determined, by direct observation, of the form of the rock floor, but the most natural deduction is, that the thickness of alluvium gradually increases from south to north, reaching its maximum at the great boundary fault, so that the Gangetic trough may be regarded as having the form of a very acute-angled wedge lying on its side, with the thick end towards the north. Mr. H. H. Hayden has recently shown that the pendulum observations of the Indian Survey support this interpretation,[1] but whether this exactly represents the case or not it is certain that the northern limit of the Gangetic trough is nearly vertical and of a depth of two or three miles, while at the southern limit the thickness of the alluvium is very small.

The effect on the direction of the plumb-line of a depression of this size and shape, filled with material which cannot have a density of more than 2·2, must be considerable, and I have had the curiosity to investigate it. The detailed results of the investigation would take up too much space to reproduce them here, nor are they suitable to this Magazine, but the general result may be indicated. I find that at the northern limit of the plain the effect would be an apparent repulsion of the plumb-bob, or in other words an apparent excess of attraction by the Himalayas, amounting to about 30″ if the depth of the alluvium is taken at 3·5 miles, and 18″ if it is taken at 1·75 miles. These values are not materially affected by any variation in the width of the alluvium. On either side of the boundary fault the deflexions decrease rapidly, but more rapidly to the south than on the north, for whereas, at 20 miles from the boundary on the north, there is still a deflexion of some 5″ or 6″ to the northwards, the northerly deflexion has almost disappeared at the same distance to the south, to be replaced, still further south, by a southerly deflexion, or apparent repulsion away from the Himalayas.

I have only indicated here the general nature of the effect which would be produced, but enough has been said to show that both in kind and magnitude it is very similar to that which has been observed, and for the explanation of which the 20 mile deep rift has been offered. Kurseong lies about 2 miles north of the main boundary fault, Jalpaiguri lies in the region where southerly deflexions should be expected, and the difference in deflexion, as

[1] Rec. Geol. Surv. Ind., xliii, pt. ii, pp. 163–7.

between the two stations, due to the effect of the less dense material filling the Gangetic trough, could not be less than 20″ and might amount to over 30″. From this it appears that without going beyond the known facts of the geological structure of the region—facts which are independent of any theory of the origin of mountains or the constitution of the interior of the earth—we can account for nearly, if not quite, the whole of the unexplained residual deflexions, which, instead of amounting to 23″ and 7″, would not come to more than 3″ or 4″, and the difference of 30″ would disappear or, at the least, be reduced to one of a few seconds of arc.

In all that has gone before I have avoided the question of the origin of mountain ranges in general, or of the Himalayas in particular, as, although I entered on the investigation, which I hope to publish in detail, with the hope that the limit of fairly established deduction might be carried further into the domain of pure speculation, I have found that the geodetic results do not give any material assistance. They have confirmed some conjectural inferences regarding the form of the rocky bed of the Gangetic depression, but on the question of the origin of the Himalayas, and of the nature of their support, the evidence is too uncertain and equivocal to be of any material value. This much, however, seems certain, that there is no good evidence for the existence of a rift of 20 miles or so in depth, as, once the known facts of geological structure are taken into consideration, the existence of such a rift would explain too much and introduce fresh difficulties even greater than those for which it was introduced as an explanation. Moreover, we must add to this negative evidence the positive fact that every observer, in every part of the range which has been visited, has found evidence of compression in precisely that zone where Colonel Burrard's postulate demands extension.

III.—The Plutonic Rocks of Garabal Hill.

By B. K. N. Wyllie, M.A., B.Sc., and Alexander Scott, M.A., B.Sc., Carnegie Research Scholars in the University of Glasgow.

(*Concluded from the November Number, p. 508.*)

At various places, such as the north side of Garabal Hill, the two Garabal burns (loc. iv and v, Fig. 1), and elsewhere, remarkably coarse rocks are found. A good section showing an apparent passage from tonalite to a coarse hornblendite is exposed at loc. v (Fig. 1). The rock in the bed of the burn is the normal tonalite, which appears to pass gradually to diorite. A closer examination of the unweathered rocks, however, shows that the passage is only apparent, and that the tonalite is clearly intrusive into the diorite with sharp junctions. The diorite near the junction is a rock of porphyritic aspect, containing large crystals of zoned diopside, abundant green hornblende and felspar, while the amount of quartz is small. A good deal of biotite is present, so that the rock might be described as a pyroxene-mica-diorite. Within a few feet the rock becomes coarser in texture, and the felspathic content diminishes, while there is a corresponding

increase in the amount of amphibole. The latter is the green hornblende common to the diorites, and is occasionally replaced by mosaics of secondary actinolite. This substitution of felspar by hornblende, accompanied by an increase in the coarseness of the texture, continues till a hornblendite containing about 85 per cent of amphibole is reached. This rock is exposed for a distance of 20 yards to the south, and then the ground is obscured by peat, so that the other margin of the diorites cannot be seen. The hornblendite consists essentially of large crystals, more or less uniform in size and up to 3 cm. in length, of green hornblende which has wholly or partly altered to brown, the alteration commencing invariably from the centre. Occasional pyroxene cores are found, and these are generally surrounded by a narrow band of green amphibole, with brown beyond and finally green margins. The interstices are filled up with aggregates of quartz, felspar, and small green hornblendes, with occasional crystals of sphene. The finer-grained varieties of this sequence probably resembled very much the hornblendite which occurs along with scyelite in the Moine Gneiss regions.[1] Occasional schlieren, resembling those already described, occur among the coarser rocks. These are generally much more felspathic than the surrounding rocks and contain long prismatic hornblendes up to 6 cm. in length.

The brown hornblende of this series differs considerably from that of the davainites. In the latter case the mineral has developed directly from pyroxene and is invariably brown, while in the former case it has formed from original green hornblende, different degrees of transformation being visible, varying from incipient alteration at the centres to completely brown crystals. The mineral shows pleochroism from deep brown to yellowish green and has strong absorption. It is generally traversed by series of parallel dark bands arranged in lattice fashion and with small outgrowths, the whole somewhat resembling arborescent microlites. Teall[2] has described similar structures in amphiboles from Cornwall and Anglesey, and Thomson[3] also found them in hornblendites from Wicklow. In these cases the dark bands were assumed to be magnetite, formed by the magmatic resorption of pyroxene and consequent replacement by hornblende. In the Garabal Burn rock a careful examination, under a high power, of the ends of the bands and outgrowths showed that they are composed of aggregates of minute pale-green or colourless crystals, orientated in irregular fashion with respect to the main direction of the bands. It seems probable that the whole of the dark bands are made up of these minute crystals, the black colour being analogous to that observed in some opaque glasses, where the opacity is due to innumerable colourless longulites, which act as prisms and disperse and totally reflect the light, the degree of opacity varying with the amount of light totally reflected.[4]

[1] *Geology of Ben Wyvis*, etc. (Mem. Geol. Surv. Scotland), 1912, pp. 128–9.
[2] *British Petrography*, 1908, pp. 475–94.
[3] Quart. Journ. Geol. Soc., lxii, pp. 475–94, 1908.
[4] Cf. Pirsson, "Artificial Lava Flow and its Spherulitic Crystallisation": Amer. Journ. Sci., ser. IV, xxx, pp. 97–114, 1910.

General Petrology.

Excluding for the moment the tonalite, and also the possible relations between the diorites and the ultrabasic rocks, we propose to consider shortly the variations exhibited by each of these two groups. Although chemical analyses have not been made of all the rocks concerned, it seems most probable that there is no great variation in chemical composition in the ultrabasic series, save where impregnation by the latter acid intrusives has occurred. The basic end-member is a pure olivine rock altered to serpentine, and with a composition approximating to that of olivine. The other end-member is the pyroxenite. The mineralogical variation could therefore be shown diagrammatically by two curves, one representing the increase of pyroxene—including hornblende—from zero to approximately 100 per cent, while the other would represent the decrease of olivine from 100 per cent to nearly zero. The chemical differences are so small, therefore, that it seems to us that local variations in the conditions are sufficient to account for them. That the intrusion did not take place all at one time is shown by the presence of the veins of porphyritic rock, the end-product of the consolidation of the magma. Hence, in a magma of such size, consolidating over a considerable period of time, the conditions could not remain uniform. Local variations in temperature and pressure would involve local partial consolidation, and therefore areas of lower potential, with the result that a potential gradient would be set up. This would be followed by intermagmatic chemical reactions, involving the formation of other molecules and resulting in local excesses of ortho- or metasilicate molecules, with an ultimate consolidation as olivine or pyroxene, as the case may be.

A similar explanation would account for the variations of the diorites. Here again we have a comparative uniformity in chemical composition, the chief variation being in the mineralogical composition, in the substitution of pyroxene by hornblende and of hornblende by felspar and biotite. Supersaturation of the magma with respect to the ferromagnesian molecules would not occur everywhere at the same temperature, with the result that sometimes the high temperature modification, pyroxene, would form, sometimes the modification stable at lower temperatures, hornblende. The amount of water dissolved in the magma would also exert some effect, as the presence of water favours the formation of hornblende, in addition to reducing the viscosity. Local richness in potash would affect the production of biotite, while pressure would be an important factor owing to the probably high molecular volume of mica. A magma from which under certain conditions pyroxene would crystallize, would, under other conditions, give hornblende or biotite.[1] Hence it seems to us that there exists no necessity to postulate any differentiation beyond what would ensue from a locally heterogeneous magma.

We will now proceed to consider the Garabal Burn series in greater detail. The texture varies greatly, as in places chilled margins

[1] Cf. Doelter, Neues Jahrb. für Min., pt. ii, p. 178 et seq., 1888; pt. i, p. 1 et seq., 1897.

which might almost be called aphanitic in structure, are found in contact with the schist, while elsewhere the crystals of hornblende average 3 cm. in width, such coarse rocks generally occurring some distance from the margins. Another significant feature is the dyke or boss-like form in which the hornblendites occur.[1] It seems to us, therefore, that they may be regarded as the roots or cores of giant apophyses of the diorite projecting into the schist roof and now laid bare by denudation. The fine-grained margins would crystallize quickly and form an impermeable envelope, which would inhibit the escape of water and other mineralizers and favour the formation of hornblende. Hence these may be compared to pegmatites on a large scale, resembling the 'peridotite-pegmatites' of Loch Garabal in the mode of formation, though the latter are on a much smaller scale. The abundance of hornblende also favours the pegmatite theory, as mineralizers such as water are essential for its formation.

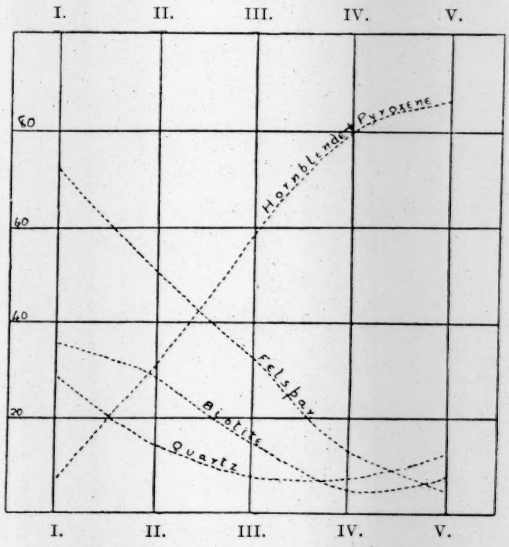


FIG. 3. Variation diagram of rocks of loc. v. Note: Quartz and biotite curves are drawn with scale of ordinates doubled.

The mineralogical variation in the rocks of this series is most easily shown by means of a diagram. A number of specimens were taken at approximately uniform distances from the tonalite and their mineralogical composition calculated by the Rosiwal method.[2] The hornblende increases from 7 to 84 per cent, while the felspar shows a complementary decrease from 70 to 5 per cent. Quartz, which is never very abundant, decreases to a minimum before the coarsest rock

[1] Hornblendites with brown amphibole have been described by Wright and Bailey in Colonsay, forming the margin of a syenite intrusion: *Geology of Colonsay* (Mem. Geol. Surv. Scotland), 1911, p. 29.

[2] No. 1 is an acid diorite from Meall Breac, while the others are from the Garabal Burn.

is reached and then increases slightly, while the biotite curve, though more irregular, as is to be expected, is very similar. The hornblende and felspar curves tend to become horizontal at the 'coarse' end where a nearly uniform rock is reached. Since these rocks show no normative quartz, the latter has obviously been formed from silica which has undergone hydrolysis at high temperatures. The increase in the water content as the coarse rocks are reached favours this.

The chemical composition, on the whole, does not show any great variations. We have analysed a specimen of the diorite close to the tonalite (VI) and one of the coarse hornblendite (VII).

	VI.	VII.	VIIa.	VIII.	IX.
SiO_2 . .	52·83	53·29	50·3	47·5	62·6
TiO_2 . .	1·82	1·41	1·6	—	—
Al_2O_3 . .	11·74	8·81	8·5	15·6	17·7
Fe_2O_3 . .	6·66	4·68	5·2	2·6	1·2
FeO . .	6·13	6·66	7·7	7·1	3·3
CaO . .	8·05	8·99	10·0	9·8	4·6
MgO . .	6·41	9·07	10·2	11·7	3·7
K_2O . .	2·06	1·87	1·6	1·5	2·5
Na_2O . .	2·67	3·21	3·2	1·4	—
H_2O . .	1·20	1·51	1·7	—	—
H_2O- . .	·20	·17	—	2·4	·7
CO_2 . .	nt. fd.	nt. fd.	—	—	—
P_2O_5 . .	·08	tr.	—	—	—
	99·85	99·67	100·0	99·7	99·7

VI. Diorite near junction with tonalite, Garabal Burn.
VII. Hornblendite, Garabal Burn.
VIIa. Approximate composition of brown hornblende of hornblendite (VII).
VIII. Diorite (very rich in biotite), Ben Damhain, anal. J. H. Player.[1]
IX. Granitite (tonalite), Ben Damhain, anal. J. H. Player.[2]

Though the silica is more or less constant, the hornblendite is somewhat more basic; that is, magnesia and lime increase at the expense of the alkalis, while the alumina decreases. These differences, however, are not sufficient to account for the mineralogical differences, as the 'norm' of the hornblendite shows a considerable amount of felspar. Hence we must conclude that the amphibole contains a considerable amount of alkali and lime, since the pyroxene which occasionally forms the core of the hornblende crystals is diopside. The amount of water has undoubtedly been an important factor in the production of the hornblende, though the relatively greater amount of magnesia must also have had an influence.

Origin of the Brown Hornblende.

The case is more difficult when we come to consider the alteration of the hornblende. There is no doubt that the mineral was originally green, and that the change originated from the centres of the crystals, unless in the case of those with diopside cores where a band of green

[1] Teall & Dakyns, loc. cit., p. 115. [2] Ibid., p. 115.

amphibole generally occurs round the diopside. It likewise seems most probable that the alteration took place after consolidation. The simplest explanation would seem to be that the change is due to the oxidation of the ferrous oxide and consequent passage of the iron from the basic radicles to the acid ones, to form ferrisilicates. The chemical analyses, however, are against this, as the hornblendite actually has less ferric iron than the diorite, while there is no reason to suppose that the brown colour of amphiboles is due essentially to ferric oxide: indeed, analyses of brown hornblende are recorded, containing only a small percentage of ferric iron. That the green hornblende is a metastable form is shown by the separation of the minute crystals of the dark bands. Since these are too small to be identified directly all that we can deduce respecting them is that they are probably monoclinic hornblende or pyroxene, since the rhombic modifications require special conditions such as would inhibit their formation in the solid state.

Two explanations suggest themselves:—

1. The brown colour may be due to ultramicroscopic crystals of the same nature as those of the feathery bands. As has been stated above, the colour of pitchstones and other glasses is often due to minute crystallites, which are too small to be resolved under the microscope, and the only evidence of the presence of which is the brown colour of the glass. Many pitchstones, too, show two generations of crystallites, one microscopic, the other sub-microscopic. Hence it is plausible to suppose that the brown colour of the hornblende has originated in this way, by the formation of innumerable crystallites of an order of magnitude lower than that of the crystals of the dark bands. The only effects on the pleochroism of the separation of such crystallites would be a uniform increase in the absorption, the difference for light waves traversing the crystal in different directions remaining practically constant, and a change in colour due to the total reflection of the light at the violet end of the spectrum.

2. On the other hand, the explanation may be that the metastable green hornblende breaks up into two more stable minerals, the minute crystallites of the dark bands and a brown hornblende. Analysis No. VIIa was obtained by deducting from analysis No. VII the amount of the various oxides which go to make up the other minerals in the hornblendite, quartz, orthoclase, andesine, and biotite, the amount of these present being calculated by the Rosiwal method. As these are only present in small amount, the error in assuming their composition as normal is negligible, and hence No. VIIa probably represents fairly closely the composition of the hornblende. Comparing this with analysis No. VI, it is seen that the amphibole of the coarser varieties contains a much greater proportion of sesquioxides than that of the finer types, as not only does more of the alumina in the latter rocks form felspar, but the iron partly crystallizes as biotite. In addition, the minute crystallites are colourless or nearly so, and hence may be assumed to be salts of lime or magnesia, with the result that their separation is accompanied by an enrichment of the residual material in 'total' iron. Thus we would have the

formation of an amphibole much richer in the oxides common to brown hornblende, accompanied by the separation of the bisilicates as the crystallites. There is very little difference between the optical properties of the two amphiboles. The extinctions are the same, as well as the positions of maximum and minimum absorption, the only difference being in the nature of the absorbed rays.

The "Newer Igneous Rocks".

The series of plutonic rocks which has been intruded into the Highland schists after the latter had been foliated are included under the general name of the "Newer Igneous Rocks". These intrusions, which are probably of Lower Old Red Sandstone age, show considerable lithological similarities. Granite usually composes the greater part, but diorites are of common occurrence, while ultrabasic rocks, on the other hand, are somewhat scarce. The only ultrabasic rocks which have been described are the peridotites of Garabal Hill, the kentallenites of Argyll,[1] the scyelites of the Moine Gneiss regions,[2] and the peridotites of the Coyles and Glen Doll,[3] each of which is accompanied by picrites. It is only in the last-named localities that we have a suite of rocks at all resembling those we have described. This includes an olivine-enstatite rock (saxonite), an enstatite-picrite, a porphyritic diorite with green hornblende, and some acid diorites. This is apparently a series of intrusions of decreasing basicity, with some rocks formed by amalgamation due to the later intrusions. A peridotite which occurs along with scyelite in Ross-shire seems to resemble the Garabal Hill wehrlite, but the scyelite itself, as well as kentallenite, are totally unlike anything occurring elsewhere, and seem to be more or less abnormal.

Wherever ultrabasic rocks occur in the Highlands they are clearly the earliest intrusion, and are usually followed by diorite and finally tonalite and granite. That some time elapsed between the various intrusions is certain, as all the evidence goes to prove that the peridotites were consolidated long before the diorites came up, and the latter had obviously crystallized before the granite intruded. Another significant feature is the absence of intermediate types. Thus at Garabal Hill we have nothing between the felspathic davainite, representing the least basic of the peridotites and with 43 per cent silica, and the hornblendites, the most basic diorite, with 49–52 per cent silica. Again, in Glen Doll, there is no rock intermediate between a picrite, containing a good deal of olivine, and a fairly normal diorite. A similar gap exists between the tonalite and diorite, for the acid diorite of Garabal Hill has about 54 per cent of silica, while the tonalite has never less than 62 per cent. Hence we have clearly three separate series of rocks, each more or less complete in itself and each showing not only the normal rock with slight

[1] Flett in *Geology of Oban and Dalmally* (Mem. Geol. Surv. Scotland), 1908, pp. 82–109.

[2] Flett in *Geology of Ben Wyvis*, etc. (Mem. Geol. Surv. Scotland), 1912, pp. 126–9.

[3] Barrow in *Geology of Braemar*, etc. (Mem. Geol. Surv. Scotland), 1912, pp. 73–83.

variations, but also the products of final consolidations in the form of schlieren; the porphyritic pyroxenite veins of Loch Garabal in the ultrabasic series, the hornblendites and the felspathic diorite-pegmatites of loc. v (Map, Fig. 1) in the diorites, and finally the aplites and acid pegmatites associated with the last intrusion.

For these reasons it seems to us exceedingly difficult to suppose that the whole of these rocks are "the result of the differentiation of an originally homogeneous magma".[1] Firstly, it is most improbable that a magma is ever in a state approaching homogeneity. Local variations of physical conditions as well as assimilation phenomena on the margins must be sufficient to keep the equilibrium heterogeneous. Secondly, while it is undoubtedly true that the basic elements would crystallize out first, the crystals thus formed would tend to sink, so that the upper parts of the magma would be relatively enriched in silica. Thirdly, the absence of intermediate types militates against the differentiation theory. This is also an argument against any theory of assimilation, as we should then expect a perfectly continuous sequence. Again, it is obvious that an original ultrabasic magma can never assimilate enough schistose material to form a tonalite, as the schist is more basic than the tonalite, while on the other hand an original acid magma could never form peridotite. In addition, it seems to us that difficulties arise when we come to consider the mechanism of differentiation. The application of Soret's principle[2] involves a large degree of diffusion and ignores, to some extent, the important rôle played by viscosity, so that its applicability is probably confined to marginal phenomena on a fairly small scale. Similar objections exist with regard to the principle of Gouy and Chaperon.[3] The difference of concentration between the top and bottom of a magma due to a gravity concentration of the heavy molecules in the dissolved state would be so small as to be negligible, unless the magma were of enormous depth.[4] It is most probable that gravity only operates on the heavy molecules where the latter form an immiscible liquid or have crystallized out. Hence it seems to us that a separate origin of the ultrabasic and the acid magmas must be postulated. While it is possible that the diorite has formed from the tonalite by assimilation, no such possibility exists with respect to the peridotites. It may be that the igneous material of the earth's crust is stratified to some extent and that the pyroxenites, etc., originated in some ultrabasic infraplutonic zone similar to that postulated by Fermor.[5] The almost invariable association of acid rocks with the earlier peridotites suggests that the former were forced up the margins of the earlier intrusions, which would constitute areas of crustal weakness and hence be the most ready outlet for the acid material. Any attempts to verify these ideas, however, are so much hampered by our

[1] Teall & Dakyns, loc. cit., p. 117.
[2] *Ann. de Chim. et de Phys.*, ser. v, xxii, pp. 293 et seq., 1881.
[3] Ibid., ser. vi, xii, pp. 384 et seq., 1887.
[4] Cf. Lehmann, *Molekularphysik*, i p. 483, etc., 1884.
[5] "Garnet as a Geological Barometer": Rec. Geol. Surv. India, xliii, pt. i, pp. 44–5, 1913.

incomplete knowledge of magmatic phenomena that they must remain as theories, and nothing more, for the present.

Note on the Diorites of Glen Lednock, Comrie.

Numerous isolated patches of diorite occur to the north-west of Loch Lomond, but no intrusion of any size is met with, except in Glen Lednock near Comrie. This occurrence is of interest because of the fact that the plutonic mass gradually passes to a hypabyssal variety of very similar composition. The plutonic rock is a fairly coarse biotite-diorite of uniform character, and is made up of mica, hornblende, felspar, quartz, and sphene, while magnetite, apatite, and zircon occur as common accessories. The mica is a deep-brown biotite with strong absorption, and is intergrown with a green hornblende, which is generally very much altered to chlorite. The felspar is partly andesine, partly orthoclase, and has apparently undergone crushing to some extent. Sometimes it is enclosed by the ferromagnesian minerals. Quartz is subordinate, while fairly large crystals of sphene occur occasionally. On the whole, this rock resembles the typical biotite-hornblende-diorite of Garabal Hill, though it has suffered much greater alteration. The rock is very uniform, the chief variation being in the relative amounts of biotite and hornblende. Very occasionally, anorthoclase occurs in addition to the other felspars.

The hypabyssal rock may be described as a diorite-porphyry, and has obviously formed as the result of quicker cooling of part of the magma. The phenocrysts include felspar, hornblende, and sphene, and show a tendency to occur in glomeroporphyritic aggregates. The felspars seem to be orthoclase, though they are generally so much altered that their determination is difficult. The hornblende has usually been replaced by fibrous aggregates of a secondary blue-green amphibole resembling actinolite; while occasionally the alteration has gone further and chlorite has developed. Sphene occurs as granular aggregates, intimately mixed up with the hornblende, though sometimes larger crystals are found. The groundmass is a micro-crystalline aggregate of quartz, felspar, biotite, hornblende, and granular sphene. The amount of quartz is small, but areas rich in sphene occur locally. The ferromagnesian minerals are found as small irregular crystals, and are accompanied by numerous cubes of magnetite. These rocks bear a close resemblance to the so-called porphyrites of Argyllshire,[1] not only in structure but also in the presence of two generations of hornblende.

Numerous veins of aplite occur in association with these rocks, differing, however, from those of Garabal Hill in some respects. The aplites of the latter area have granitic affinities, and are made up of quartz and alkali-felspar with subordinate muscovite. Those of Glen Lednock, on the other hand, are related to the syenite family, and contain orthoclase with abundant biotite, while quartz and plagioclase are subordinate.

[1] *Geology of Cowal* (Mem. Geol. Surv. Scotland), 1897, p. 103; Hill in *Geology of Mid-Argyll* (ibid.), 1905, pp. 103–15; Flett in *Geology of Oban and Dalmally* (ibid.), 1908, pp. 96–102.

Obviously, we have here an intrusion of the same nature as the diorite intrusion of Garabal Hill, but differing from the latter by the fact that part has undergone more rapid cooling, and hence has formed the diorite-porphyry. Analogous rocks, however, occur in the Strath Dubh Uisge valley, where a few dykes of very decomposed felspar-porphyry outcrop. An occurrence of diorite apparently passing to porphyrite has been described from Loch Melfort,[1] but the Geological Survey are of the opinion that the porphyrite is an earlier intrusion which has been altered by the diorite. In the island of Colonsay intrusions of augite-diorites have been found, grading to lamprophyres on the margins.[2] The junctions of the different types in Glen Lednock are very obscure, and hence the relations between the rocks cannot be ascertained.

IV.—On the Important Part played by Calcareous Algæ at certain Geological Horizons, with Special Reference to the Palæozoic Rocks.

By Professor E. J. Garwood, M.A., V.P.G.S.[3]

(*Concluded from the November Number, p. 498.*)

(WITH FOLDING TABLE II.)

Solenopora.—The discovery of this genus in the Lower Carboniferous rocks of Westmorland is of considerable interest, as its occurrence here gives us some insight into the history of its wanderings between the time when we last recorded it in the Gotlandian rocks of the Baltic area and its subsequent reappearance in the Lower Oolite of Gloucestershire. Whether it lived in the Baltic area during the Devonian and Carboniferous periods is, however, still unknown. The fact of its occurrence in the Caradoc, Carboniferous, and Jurassic rocks of the British Isles would appear to point to its existence not far off during the intervening periods.

In Westmorland and Lancashire *Solenopora* occurs in considerable abundance near the local base of the Lower Carboniferous rocks, and contributes largely to the formation of limestone deposits. It is present wherever the lowest beds of the succession are exposed, as at Shap, Ravenstonedale, and Meathop, and must formerly have flourished over a considerable area.

Though bearing a general resemblance, both in hand specimens and in microscopic structure, to the Ordovician and Jurassic forms, it has recently been shown by Dr. G. J. Hinde to be specifically distinct.[4] It occurs as small, spheroidal nodules up to an inch in diameter, having a markedly lobulate outline embedded in compact and usually dolomitic limestones, and it is occasionally associated with oolitic structure. When fractured it exhibits the compact porcellanous

[1] Flett in *Geology of Oban and Dalmally* (Mem. Geol. Surv. Scotland), 1908, p. 69.

[2] Wright & Bailey, loc. cit., pp. 33–4.

[3] Edited and slightly abridged with the author's permission from the original Address as delivered at Birmingham, before Section C at the British Association meeting.

[4] Geol. Mag., Dec. V, Vol. X, p. 289, 1913.

texture and pale brownish tint characteristic of other species of this genus, while weathered surfaces frequently show a concentric and occasionally a radially fibrous structure. The profusion of this form in Westmorland would lead one to expect its occurrence in other districts where the lowest Carboniferous zones are developed; but so far as I am aware, no such occurrence has yet been recorded. It may be of interest, therefore, to mention here that a few years ago my friend Mr. P. de G. Benson brought me a specimen of rock from near the base of the succession in the Avon Gorge, which on cutting I found to contain several examples of *Solenopora* identical with the Westmorland form.

Mitcheldeania.—The specimens of *Mitcheldeania Nicholsoni* originally described by Mr. Wethered were obtained from Wadley's Quarry, near Drybrook, Mitcheldean, from the Lower Limestone shales near the base of the succession. Professor Sibly, who has recently made a careful study of the Lower Carboniferous succession in the Forest of Dean,[1] has traced this algal layer over a considerable area, and considers it to represent an horizon near the top of K.II. of the Bristol sequence. He has also noted examples of *Mitcheldeania* at a higher level—namely, in the Whitehead Limestone, an horizon corresponding probably to the base of C.2. During a recent visit to the Mitcheldean district I collected specimens from the lower shales and also from the Whitehead Limestone, and, thanks to Professor Sibly's kind directions, I was able to see numerous sections in which he has found this algal development. There can be no doubt that *Mitcheldeania* is here an important rock-forming organism at least at two horizons in this district, and that it occurs over a considerable area. Interesting as the development of *Mitcheldeania* in the Forest of Dean undoubtedly is, its real home in Britain is in North Cumberland and along the Scottish Border, where it flourished to a remarkable extent in the shallow-water lagoons which spread over so large an area in the North of England during early Carboniferous times. Over the greater part of North Cumberland and the east of Roxburgh we find a remarkable development of algal limestones in the formation of which *Mitcheldeania* plays a very important part. It is met with especially at two horizons—an upper one, lying immediately below the Fell Sandstone, and a lower one in the middle of the underlying series of limestone and shales. The lower horizon is especially interesting on account of the thick masses of limestone composed almost entirely of algal remains. Though *Mitcheldeania* forms the basis of this reef-like development, it is accompanied by other algal forms, especially bundles of the minute tubules of *Girvanella* together with coarser tubes reminding one of the *Sphærocodium* deposits of Gotland; in places again the marked concentric coatings resemble certain forms of *Spongiostroma*. The substance of the reef has frequently formed round the remains of Orthoceratites—indeed, the chief layer is usually associated with remains of these Cephalopoda. With other layers occur tubes of *Serpulæ* and remains of Ostracoda. In addition to the limestone of this massive reef, abundant nodules of *Mitcheldeania* lie scattered through the calcareous shales both above and below.

[1] Geol. Mag., Dec. V, Vol. IX, p. 417, 1912.

The upper horizon from which Nicholson obtained his type-specimen of *M. gregaria* at Kershope Foot forms a compact limestone several inches thick. It is made up of small spheroidal nodules about half an inch in diameter, and occurs a short distance below the Fell Sandstone. It can be traced over the whole of North Cumberland and north-west Northumberland from near Rothbury on the east to the Scottish Border at Kershope Foot, and from the headwaters of the Rede in the north to the Shopford district in the south. This layer must therefore have been originally deposited over an area of at least 1,000 square miles. The horizon of the upper band is almost certainly that of the C zone of the Bristol sequence.[1] It is quite possible, therefore, that it is contemporaneous with the Whitehead Limestone of Mitcheldean. This supposition receives support from two other pieces of evidence. In the beds underlying the *Mitcheldeania gregaria* band in North Cumberland occur calcareous nodules largely made up of tubes of *Serpulæ*—an organism which is completely absent from the Westmorland succession, but which is reported by Professor Sibly from the lower limestone shales containing *Mitcheldeania* in the Forest of Dean district. Again, this upper algal layer in Northumberland and Cumberland is almost immediately overlain by the Fell Sandstone Series, while the Whitehead Limestone at Mitcheldean passes immediately upwards into a sandstone, the Drybrook Sandstone of Professor Sibly, which was originally correlated with the Millstone Grit, but was shown by Dr. Vaughan in 1905 to belong to the Lower Carboniferous Series. It would be interesting if further researches should prove the existence of a former gulf at the end of Tournaisian times, running from the Forest of Dean to the east of North Wales, through North Cumberland to the southern slopes of the Cheviot Isle, with a branch given off eastward into Westmorland.

In any case it is a remarkable fact that we have a great development of algal deposits at this period in Gloucestershire, Westmorland, Lancashire, North Cumberland, and Northumberland.

Ortonella.—This form, as already mentioned, occurs in great abundance in the algal band in the '*Athyris glabristria* zone' of the North-West Province. It is found in spherical nodules up to the size of a small orange. In microscopic sections it resembles *Mitcheldeania* in so far as it consists of a series of tubes growing out radially from a centre. It differs, however, from this genus in many important respects. All the tubes are approximately of the same size, and there is no evidence of alternating coarse and fine tufts arranged concentrically, as in the case of *Mitcheldeania*. Further, the tubes are not undulating as in that genus, and therefore in thin slices lie for a long distance in the plane of the section. They are much more widely spaced and show marked dichotomous branching, the bifurcations making a nearly constant angle of about 40°, and there is a strong tendency for the branching to take place in several tubes at about the same distance from the centre of growth, producing a general concentric effect in the nodule.

[1] *Geology in the Field*, pt. iv, p. 683, and Q.J.G.S., vol. lxviii, p. 547, 1912.

The diameter of the tubes is decidedly less than those in *Mitcheldeania*, being usually little more than half the size of the larger tubes of *M. gregaria*. The nodules of this genus occur in great profusion, contributing largely to the formation of the shaly dolomite at the base of the '*P. globosus* band' throughout the Shap, Ravenstonedale, and Arnside districts in Westmorland and Lancashire.

In addition to these genera there occur also two other encrusting calcareous growths which require mention. The first of these appears in thin sections in the form of a 'festoon-like' growth, surrounding fragments of Calcareous Algæ, especially *Mitcheldeania* and *Ortonella*. I have met with it abundantly in the 'Algal band' in the north-west of England, but it also occurs not infrequently associated with *Mitcheldeania* in the Whitehead Limestone in the Forest of Dean, while a similar structure occurs associated with *Mitcheldeania gregaria* in North Cumberland.

The other deposit is the form already alluded to under the term *Sphærocodium*, which I have found forming considerable masses of rock in many districts where the Lower Carboniferous beds are exposed, not only in Westmorland and North Cumberland, but also in the Bristol district, the Forest of Dean, and South Wales.

Foreign Carboniferous.

From its general similarity to the British deposits we might expect to find examples of an algal development in some portion of the Belgian Lower Carboniferous succession. As already mentioned, large masses of encrusting calcareous deposits have been described by Gürich[1] from the Visean Limestones of the Namur Basin as *Spongiostroma*, etc., which, though referred by him to the Rhizopoda, may very well be calcareous precipitates deposited by algal influence. Many of these deposits are similar to those mentioned above from British rocks.

No undoubted remains of Calcareous Algæ have, however, yet been recorded from these Belgian rocks. It may be of interest, therefore, to mention the recent discovery by Professor Kaisin, of Louvain, of certain algal remains in the beds overlying the Psammites-de-Condroz at Feluy on the Samme. The form found here resembles *Ortonella* of the Westmorland rocks, but the tubes are much finer, and it may turn out to represent a species of *Mitcheldeania*. During a recent visit to Belgium I had the pleasure of visiting the Comblain-au-Pont Beds, in the Feluy section with Professor Kaisin, and, although these beds have been previously classed as Devonian, I agree with him that they probably belong to the base of the Carboniferous and correspond approximately to K of the Bristol sequence. In the company of Professor Dorlodot and Dr. Salée, I also visited the chief sections of the Visean, and we succeeded in discovering at least three horizons at which nodular concretionary structures, probably referable to algal growths, occurred.

In 1908 Schubert (Jahrb. d. k. k. geol. Reichsanstalt, 1908, Bd. 58, Hft. 2, pp. 347, 382, pl. xvi, figs. 8–12) published descriptions of two new forms of the Siphoneæ—*Mizzia* and *Stolleyella*—from the

[1] Mém. du Musée Roy. d'Hist. Nat. de Belgique, t. iii, 1906.

Fusulina Limestone of the Velebit district in Dalmatia, while later, in 1912 (Verh. d. k. k. geol. Reichsanstalt, 1912, p. 330), he records further examples of these genera from specimens, collected by Koch, of rocks of the same age in Croatia. The same genera have also been recorded by Karpinsky from the Fusulina Limestone of Japan (Verh. d. Russ.-kais. Min. Gesell. St. Petersb., ser. II, Bd. 46, 1908, p. 257, pl. iii).

Still more recently another form of *Girvanella* has been described by Yabe from the (?) Carboniferous rocks of San-yu-tung and other localities in China under the name of *G. sinensis*.[1]

Permian and Trias.

In Britain I have met with no reference to the presence of Calcareous Algæ in rocks of this period, but quite recently Mr. Cunnington, of H.M. Geological Survey, sent me a few nodules from the base of the Permian near Maxstoke; in thin sections they resemble very closely specimens of *Spongiostroma* from the Carboniferous Limestone described above.

On the Continent masses of limestone, composed almost entirely of remains of *Diplopora* and *Gyroporella*, have long been known from the Muschelkalk and Lower Keuper beds of the Eastern Alps, notably the Mendola Dolomite, the Wetten Limestone of Bavaria, and from similar horizons in Tyrolian Alps. In the Lombard Alps the same facies reappears, and *Diplopora annulata* occurs abundantly in the well-known Esino Limestone above Varenna, while recent work by Cayeux (C. R. Acad. Sci., Paris, tome clvii, p. 272, 1911, and Exploration Arch. de Délos, Paris, vol. iv, pt. i, 1911), Négris (C. R. Acad. Sci., Paris, tome clv, p. 371, 1912), and Renz (Centralb. f. Min., 1911, pp. 255, 289, and ibid., 1912, p. 67; also Jahrb. österr. geol. R. A., lx, pt. iii, p. 451, 1910) on the Triassic rocks of the mainland of Greece and the Cyclades shows the wide distribution of the Algal limestones in the south and south-east of Europe.

In 1891 Rothpletz[2] showed that certain spherical bodies in the Triassic beds of St. Cassian, formerly regarded as oolitic structures, were in reality algal growths, and referred them to a new genus, *Sphærocodium*, on account of their apparent resemblance to the living form *Codium*. He describes them as encrusting organisms forming nodules up to several centimetres in diameter. They contribute substantially to the rocks in which they occur, and are found especially in the Raiblkalk, the Kossenerkalk, and the Plattenkalk.

Jurassic.

The Mesozoic rocks of Britain contain but few examples of marine algal limestones, and important occurrences are confined to the Jurassic rocks. The forms met with are limited to two genera, *Girvanella* and *Solenopora*.

Tubes of *Girvanella* occur fairly abundantly in the British Oolites, especially in the well-known Leckhampton Pisolites, and Mr. Wethered, who has made a special study of oolitic structures, appears inclined to refer all oolitic structures to organic agency of this nature.

[1] H. Yabe, Science Reports of the Tôhoku Imp. Univ., ser. II, Geology, vol. i, No. 1, Japan, 1912.

[2] Zeitsch. d. deut. Geol. Ges., vol. xliii, pp. 295–322, pls. xv–xvii, 1891.

The examples of *Solenopora* met with in the Great Oolite[1] and Coral Rag are of special interest. In both cases they attain very much larger dimensions than any species yet discovered in the Palæozoic rocks.

At Chedworth, near Cirencester, I have collected masses of *Solenopora jurassica*, measuring up to a foot across, in which the original pink tint is still so conspicuous on freshly fractured surfaces as to give rise to the local appellation of 'Beetroot Stone', and the colour also reminds one of the red algæ growing in great profusion at the present day in the Gulf of Naples.

It is also recorded from the same horizon by Dr. Brown[2] from near Malton in Yorkshire, and also, on the authority of the late Mr. Fox Strangways, by Rothpletz.[3]

In Yorkshire, however, one form undoubtedly occurs at a higher horizon, namely, in the Coral Rag of the Scarborough district, where it is well known to local collectors. Specimens which I have collected from this horizon at Yedmandale and Seamer also attain a considerable size—up to 3 inches in their longest dimension.

The name *Solenopora jurassica* was given by Nicholson in manuscript to specimens from Chedworth, and was adopted by Dr. Brown in his description of the specimens from both Chedworth and Malton in Nicholson's collection.

Rothpletz points out that specimens examined by him from Yorkshire differ from the genotype in the fact that the cells are typically rounded in cross-section and by the absence of perforations in the cell-walls, and he therefore proposes to separate it as a new genus *Solenoporella*. It seems probable that some confusion has arisen between the specimens to which Nicholson originally gave the name of *S. jurassica* from the Great Oolite of Chedworth and other specimens from Malton from a higher horizon[4]—the Coral Rag. I have collected specimens from both horizons and consider that the Chedworth specimens, to which the name *Solenopora jurassica* was originally given, represent a species of true *Solenopora*, showing closely packed cells with polygonal outline in tangential section; the form from the Coral Rag of Yorkshire, with distinct circular outline to the tubes in tangential section, is specifically, if not generically distinct, and is that described by Rothpletz as *Solenoporella*.

If this view be correct we should continue to speak of the specimens from the Great Oolite at Chedworth as *Solenopora jurassica*, while those from the Coral Rag of Yorkshire must be known as *Solenoporella* sp., Rothpletz.

Foreign Jurassic.

In foreign Jurassic rocks the recorded occurrences of Calcareous Algæ are surprisingly few.

Quite recently, however, Mr. H. Yabe[5] has described a new species of *Solenopora*, under the title *Metasolenopora Rothpletzi*, from the

[1] Proc. Cot. Nat. Club, vol. x, p. 89, 1890.
[2] GEOL. MAG., Dec. IV, Vol. I, pp. 145 et seqq., 1894.
[3] Kungl. Svenska Vet. Akad. Handl., Bd. xliii, No. 5, 1908.
[4] See Fox Strangways, GEOL. MAG., Dec. IV, Vol. I, p. 236, 1894.
[5] Sci. Rep. Tôhoku Imp. Univ. Japan, 1912.

Torinosu Limestone, Japan. This discovery is of interest, as it carries the known occurrence of *Solenopora* up to the base of the Cretaceous, in which formation *Lithothamnion* appears and thenceforward becomes the chief representative of the rock-building Coralline Algæ.

Cretaceous.

We here reach the period when *Lithothamnion* and its allies begin to make their appearance. They have not yet been recognized in British rocks, but are widely distributed in deposits on the Continent. They occur in the Cenomanian of France, in the Sarthe and the Var, but especially in the Danian of Petersburg, near Maestricht.

Other forms which may be mentioned are *Diplopora* and *Triploporella*. The former is met with abundantly in the Lower Schrattenkalk in certain districts, especially Wildkirchli, where it plays a considerable part in the formation of the deposit.[1]

Tertiary.

In Britain no example of marine Calcareous Algæ have, so far as I am aware, yet been reported, but considerable deposits of freshwater limestone, rich in remains of *Chara*,[2] have for long been known from the Oligocene of the Isle of Wight.

Foreign Tertiary.

On the Continent, however, thick deposits rich in *Lithothamnion* and *Lithophyllum* have been known for many years. Of these I may mention especially the well-known Leithakalk of the Vienna Basin and Moravia. It will be remembered that it was these deposits which formed the subject of Unger's important monograph in 1858.[3]

Conclusions.

The facts given above regarding the geological distribution and mode of occurrence of these organisms lead us to several interesting conclusions. In the first place there can be no doubt from the examples described above that they play a very striking part as rock-builders at many different horizons in the geological series. At the same time it is evident that not only are certain forms restricted to definite geological periods but also that they had a wide geographical range, and on this account these organisms will often be found valuable as zonal indices either alone or in conjunction with various other organisms. As an example of this wide distribution we may cite *Solenopora compacta*, which flourished so abundantly during Llandeilo–Caradoc times not only in the Baltic area and Scotland but also in England, Wales, and Canada; again, the wonderfully persistent development of the *Rhabdoporella* facies over the whole of the Baltic area at the close of Ordovician times was of so marked a character that even boulders of these rocks scattered over the North German plain can be made use of in tracing the direction of flow of the ice-sheet during Glacial times.

[1] Arbenz. Vierteljahrsschr. Naturf. Ges. Zurich, vol. liii, pp. 387–92, 1908.

[2] This form, though till lately included among the green algæ, is now usually placed in a distinct group—the Charophyta.

[3] Denksch. k. Akad. Wiss. München, vol. xiv, p. 13, 1858.

To take examples nearer home. The '*Ortonella* Band' found throughout Westmorland and North Lancashire near the summit of the Tournaisian occurs so constantly at the same horizon as to constitute one of the most valuable zonal indices in the succession in the North-West Province, and can not only be used with the greatest confidence for correlating widely separated exposures, but it has also afforded valuable evidence of tectonic disturbances. Other examples are supplied by the '*Girvanella* Nodular Band' at the base of the Upper Dibunophyllum Zone, and the *Mitcheldeania gregaria* beds in the North of England and in the Forest of Dean.

Again, the presence of these organisms at particular horizons furnish us with interesting evidence as to the conditions which obtained during the accumulation of the deposits in which they occur.

At the present day Calcareous Algæ flourish best in clear but shallow water in bays and sheltered lagoons. As a good example we may take the Algal banks in the Bay of Naples, described by Professor Walther,[1] where *Lithothamnion* and *Lithophyllum* flourish to a depth of from 50 to 70 metres. There is seldom any muddy sediment on these banks, though detrital limestone fragments are widely distributed. Another interesting point is the constant association of fossil Calcareous Algæ with oolitic structure and also with dolomite.

Thus oolites occur in connexion with *Solenopora* in the Lower Cambrian of the Antarctic, in the Craighead Limestone at Tramitchell, in the Ordovician rocks of Christiania and the Silurian of Gotland, and in the Lower Carboniferous Limestone of Shap; while in the Jurassic rocks of Gloucestershire and Yorkshire this genus occurs associated with the most typical oolitic development to be met with in the whole geological succession. Though Mr. Wethered has made out a good case for the constant association of *Girvanella* tubes with oolitic grains there are many cases in which this association cannot be traced. M. Cayeux[2] in writing of a mass of *Girvanella* from the ferruginous oolites of the Silurian rocks of La Ferrière-aux-Etangs expresses his opinion that *Girvanella* encrusts the oolite grains but does not form them, and that it is really a perforating alga of a parasitic nature.

The presence of dolomites in connexion with algal growths at different geological horizons appears to show that the beds have accumulated under definite physiographical conditions similar to those which obtain to-day in the neighbourhood of coral reefs. Such lagoon conditions would tend to come into existence during periods of subsidence or elevation, and this is just what we find when we examine the periods at which these reefs are most persistent.

Thus the Girvan Ordovician lagoon-phase occurred during an elevation which culminated with the deposition of the Benan Conglomerate; the Lower Carboniferous 'Algal band' in Westmorland was laid down during the subsidence which followed the Old Red Sandstone continental period, while the Upper *Girvanella* Nodular band occurred

[1] Zeitsch. deut. Geol. Ges., 1885, p. 229. Abh. Königl. Preuss. Akad. Wiss., 1910.

[2] Comptes Rendus Acad. de Sci. 150, 1910, p. 359.

Formations.	British Localities.		Baltic Provinces.	North America.	Middle Europe.	Alps, etc.	South Europe.	Asia.	Japan and Philippines.	Australia and Madagascar.	Antarctic.
Newer Tertiary .	—	—	—	—	—	—	*Lithothamnion*; Girgenti.	—	—	—	—
Miocene . .	—	—	—	—	—	Leithakalk, with *Lithothamnion*, Vienna Basin and Moravia.	*Lithothamnion*: Alhama, etc., Spain.	*Lithothamnion*: Lake Wan, Armenia.	*Lithothamnion*: Philippines.	—	—
Oligocene . .	—	—	—	—	—	*Lithothamnion*: Val Sugana.	—	—	—	*Lithothamnion*: North Madagascar.	—
Eocene . .	—	—	—	—	*Lithothamnion*: Ariege. *Dactylopora*: Paris (Calcaire Grossier).	—	—	*Lithothamnion*: Trebizond, etc., Armenia.	—	—	—
Cretaceous . .	—	—	—	—	[Danian & Senonian] *Lithothamnion*: Maestricht, Marseilles; Pisolitic Limestone, Paris.	*Diplopora*, *Triploporella*: Schrattenkalk, Wildkirchli.	—	Turonian—*Triploporella*: Lebanon.	—	—	—
Jurassic . .	—	—	—	—	—	*Diplopora*.	—	—	*Metasolenopora*: Japan (Torinosu Limestone).	—	—
Purbeck.	—	—	—	—	—	—	—	—	—	—	—
Coral Rag.	*? Solenoporella* .	Yedmandale, Seamer, Ruston, etc., and Malton.	—	—	—	—	—	—	—	—	—
Great Oolite.	*Solenopora jurassica*	Chedworth, near Cirencester.	—	—	—	—	—	—	—	—	—
Trias . . .	—	—	—	—	*Diplopora*: Alsace-Lorraine (Muschelkalk).	*Diplopora, Gyroporella, Sphærocodium*: Tyrol (Wengen St. Cassian, etc.). *Diplopora, Gyroporella*, etc.: Lombardy (Esino Limestone). *Gyroporella*: S. Tyrol.	*Diplopora, Gyroporella*: Greece, mainland, and Cyclades.	—	—	—	—
Permian . .	*? Spongiostroma* .	Maxstoke, near Coventry.	—	—	—	—	—	—	—	—	—
Carboniferous—Upper & Lower .	—	—	—	—	—	*Mizzia, Stolleyella*: Velebit, Dalmatia, and Croatia.	—	'Calc-Algæ': Lake Urmi, Armenia.	*Mizzia, Stolleyella*: Akasaka, Mino, Japan. *Girvanella sinensis*: Carboniferous? Japan.	—	—
Base of Upper *Dibunophyllum* zone.	*Girvanella* . .	Coldstream, Penygent, Humphrey Hd., etc., Tortworth, Clifton.	—	—	*Spongiostroma*: Visean of Namur.	—	—	—	—	—	—
Athyris glabristria zone.	*Ortonella* . . .	Shap, Orton, Ravenstonedale, Meathop, etc.	—	—	Lowest *Ortonella* or *Mitcheldeania* at Feluy.	—	—	—	—	—	—
	Solenopora Garwoodi	Shap Abbey, Stone Gill,[1] Meathop, Clifton.	—	—	—	—	—	—	—	—	—
	Mitcheldeania gregaria, Mitcheldean Whitehead Group	Scottish Border, Cumberland, Northumberland.	—	—	—	—	—	—	—	—	—
	M. Nicholsoni, Mitcheldean, Lower Limestone Shales	Scottish Border and Cumberland.	—	—	—	—	—	—	—	—	—
	? Spongiostroma .	Widely distributed at several horizons, especially at Orton.	—	—	—	—	—	—	—	—	—
Devonian . .	*? Girvanella* . .	Hope's Nose Limestone.	—	—	U. Devonian, Silesia: *Sphærocodium Zimmermanni*.	*Sycidium*? Eifel.	—	—	—	—	—
Silurian—Ludlow.	—	—	*Spongiostroma, Sphærocodium gotlandicum, Solenopora gotlandica*: Gotland.	—	—	—	—	—	—	*Girvanella ? Mitcheldeania*.	—
Wenlock.	*Girvanella problematica* (?)	Mayhill, Malvern, etc.	—	—	—	—	—	—	—	—	—
Ordovician—Upper Caradoc. Ardmillan Series (Whitehouse Group).	*Solenopora lithothamnioides*	Shalloch Mill, Girvan.	*Rhabdoporella, Vermiporella, Apidium*, etc.: Bergen, Christiania, South Sweden, Esthonia. *Solenopora compacta*: Christiania, Esthonia.	*Solenopora compacta*: Trenton Limestone, Black River Limestone.	—	—	—	—	—	—	—
Llandeilo-Caradoc (Stinchar and Craighead Limestone).	*Girvanella problematica*	Girvan district.	—	—	—	—	—	—	—	—	—
	Solenopora compacta, var. *Peachii*, *S. fusiformis*, *S. filiformis*	Girvan district; Hoar Edge, Shropshire; Yat Hill, Radnorshire.	—	*Girvanella* (*Strephochetus*): Chazy Limestone.	—	—	—	—	—	—	—
Cambrian . .	—	—	—	—	—	—	*Girvanella* (*Siphonema*): Sardinia.	*Girvanella*: Man-t'o Series, China.	—	*Girvanella.*	*Solenopora* (Beardmore Glacier).

when the marine period of the Lower Carboniferous was drawing to a close and a general elevation was taking place. Similar conclusions could be drawn from the Gotlandian and other periods recorded above.

In conclusion I venture to express the hope that however incomplete the account of the succession of forms which I have given may be, it may nevertheless help to stimulate an interest in these rock-building Algæ and encourage geological workers in this country to turn their attention to a hitherto neglected group of forms of great stratigraphical importance.

In the accompanying Table II are set out the more important Algal horizons so far described in the Palæozoic and Mesozoic rocks, together with a few typical occurrences of Tertiary age, but the table makes no claim to be exhaustive, as additional evidence of the importance of these organisms is constantly coming to hand; thus since the publication of the last number of this Magazine I have received from Professor Rothpletz[1] a description of a new form of Spherocodium, *S. zimmermanni*, which he finds playing an important part in the 'so-called conglomerate' in calcareous sandstone near Liebichan Silesia, formerly classed as Culm, but which has recently been shown by Zimmermann to be of Upper Devonian age.

V.—The Sub-crag Flints.

By J. Reid Moir, F.G.S.

At the meeting of the British Association held at Birmingham last September, Professor W. J. Sollas, F.R.S., read a paper in which the Sub-crag flints I have discovered were rejected as not being of human workmanship. Professor Sollas mainly based his arguments upon certain flints found upon the seashore at Selsey Bill, Sussex, many of which have been collected by Mr. E. Heron Allen of that place. In August of this year I paid a visit to Selsey and, owing to the kindness of Mr. Heron Allen, was enabled to carefully examine his collection of flints and the exact places on the shore from which they were derived.

The conclusions I arrived at regarding these specimens and their method of fracture are as follows:—

An examination of the flints in Mr. Heron Allen's collection from the surface of the Eocene clay at Selsey Bill clearly shows that they differ widely both in mineral condition and 'patination', and do not belong to one geological period. When each series is arranged apart the specimens are seen to resemble very closely those found in East Anglia (1) below the Red Crag, (2) in the Middle Glacial Gravel, and (3) in the Chalky Boulder-clay.

The occurrence of flints of these three series at one horizon in the South of England is of some interest and importance, and seems to indicate the breaking up of these deposits and subsequent deposition of their material at the spot where they are now found. The specimens

[1] "Über *Sphærocodium Zimmermanni* aus dem Oberdevon Schlesiens": Jahrb. d. k. Preuss. Geol. Landesanstalt, 1911, Bd. xxxii, T. ii, Hft. i, p. 112, pls. 4, 5.

have naturally had a lot of rough usage while being transported from one site to the other and have also suffered considerable disintegration, as is clear from the cracked condition of the lumps. Prolonged examination of the East Anglian flints from the three horizons mentioned has shown that those below the Red Crag are hard and sound, while those from the Middle Glacial Gravel and Chalky Boulder-clay are much more easily cracked and broken up.

It is therefore very interesting to find that the same rule holds good at Selsey, where specimens, apparently of the same age as the Sub-crag samples of East Anglia, are not so much broken as those which appear to have come from Middle Glacial and Chalky Boulder-clay deposits.

The 'Sub-crag' specimens from Selsey are in some cases humanly flaked, and the flaking is in every way the same as that seen upon the East Anglian flints. The flakes are large and have been removed by blows of considerable force delivered in a vertical direction and resulting in smooth, clean surfaces, generally free from conchoidal rippling. Fissures or small 'splits', radiating from the point of impact, are very often developed upon the surface of the flakes, which frequently required repeated blows to detach them from the block. The flints also exhibit a dark rich brown colour, and in many cases well-marked 'weathered-out' scratches. These peculiarities are to be seen upon the East Anglian Sub-crag specimens, and moreover the forms of worked flints from the two sites are almost exactly similar.

(Mr. Heron Allen tells me that the smaller Sub-crag types such as borers, scrapers, etc., have not been found at Selsey.)

Out of the large series of Selsey flints about twelve have been definitely worked by man, and only four of these were undamaged and in a good state of preservation. These were all of a Sub-crag type; some of the others may at one time have exhibited human work, but if so, subsequent natural fracturing has effectually disguised it.

In order to demonstrate that the flints with cracks running through their mass could easily be disintegrated, I dropped one upon a tougher specimen, and, as I expected, the impact was sufficient to shatter it in pieces. Some of these fragments, which of course bore no real resemblance to man's work, were of a somewhat suggestive shape, and if subjected to some amount of rolling by the sea might very well deceive an unpractised eye.

A visit to the exposure of these flints on the foreshore confirmed the belief that the sea is at the present day breaking up the blocks, and a single tap of the hammer is often enough to reduce them to fragments. It is clear that the large majority of the Selsey specimens have been fractured in the manner I describe, and a comparison of the fractured surfaces with those produced by my experiment shows an exact agreement. There is the same dull, lustreless appearance, the same uneven 'hackly' fracture, and the same indisputable evidence that the flint has broken along the lines of least resistance. There is also no sort of resemblance in these fractures to those on the other specimens which have been produced by heavy well-directed human blows.

The fact that the Selsey specimens are found upon the present seashore has induced some observers to assert that all the fractures have been caused by wave-action on the shore, and that it is possible to observe the process actually going on. The latter fact is not denied, and indeed has been tested by experiment, but the fractures so produced are quite distinct from those attributed to human agency. It is also quite clear that wave-action on the present beach has simply removed typical 'natural' flakes, that is those which have been caused by blows falling on an edge instead of at the side of it, the former showing prominent ripple-marks owing to the blows being oblique instead of vertical. These 'natural' flakes are never very large, and often cut deeply into the flint, developing into a 'step' at the end opposite to the point of impact.

The alleged discovery of a rostro-carinate 'implement' fixed in the Eocene clay and in process of manufacture must, I think, be received with very great caution, especially as it appears that the ventral plane, from which the flakes are generally removed to form the carina, was turned towards the shore, and therefore not exposed to the hypothetical battering of the stones brought in by the sea.

The small series of flints collected by Mr. Heron Allen shows a fundamental difference, which is best explained by the difference known to exist between human and natural flaking, the presumed implements being picked out with ease from others which are obviously formed by natural agencies. Moreover, there appear to be no transitional forms, the two series being sharply enough defined for those familiar with the fracture of flint. The 'human' series examined on this occasion contains no typical rostro-carinate implements, and the superficial resemblance of others to that type will not bear investigation.

VI.—On some Foraminifera from the Eocene Beds of Hengistbury Head, Hampshire.

By Frederick Chapman, A.L.S., F.R.M.S., Palæontologist to the National Museum, Melbourne.

In the March Number of this Magazine Mr. Cowper Reed recorded the interesting discovery of a series of fossils which points to a Bartonian horizon for the Hengistbury ironstone. Upon reading this paper I was reminded of some chocolate-coloured clays with Foraminifera which I had collected from a seam between the ironstone bands at Hengistbury Head in August, 1895. The washings from these clays afforded abundant tests of arenaceous forms; and since, so far as I am aware, no Foraminifera have yet been recorded from this locality, it may be of some interest to publish the results of an examination of the material collected.

From my notebook I find this sample, chocolate-coloured sandy clay with glauconite, was collected between the two ironstone bands on the west side of Hengistbury Head. No direct evidence could be gathered from the present series as to relationship with the Foraminifera of the Barton or Bracklesham Beds, from both of which

formations I had collected on an extensive scale. The tests are all arenaceous, the facies representing a somewhat different hydrographic condition from that of the deposits belonging to the two last-named series, represented in my collection from the Barton Cliffs, Bracklesham Bay, and from many typical exposures in the Isle of Wight.

Description of the Foraminifera.

Fam. LITUOLIDÆ.

Genus Haplophragmium, Reuss.

Haplophragmium canariense, d'Orbigny, var. *pauperata*, nov. Figs. 1–4.

This variety is distinguished from the specific type [1] by its small and distorted condition, often accompanied by a deflation of the finely arenaceous walls of the chambers. The more regular examples, of which there are one or two exceptional cases, link themselves with *H. canariense*, of cosmopolitan distribution.

The variety is smaller than type-specimens of the species, the former averaging ·58 mm. in greatest diameter, whilst the latter measures ·84 mm. (*Challenger* example).

H. canariense, var. *pauperata* is moderately abundant in the washings from the clay seams of Hengistbury Head.

Genus Lituola, Lamarck.

Lituola simplex, Chapman. Figs. 7, 8.

Lituola simplex, Chapman, 1904, Rec. Geol. Surv. Vict., vol. i, pt. iii, p. 228, pl. xxii.

Several sub-discoid and crosier-shaped tests, very thin and compressed, and consequently very fragile, were found in the washings. They can be distinguished from mere adventitious flakes or concretions of mud by their simulation of the depauperated and compressed forms of *Haplophragmium* and *Trochammina*. Their obscurely septate and labyrinthic internal structures make them come within the Lituolid group.

The original examples above quoted were from similar washings of chocolate-coloured clays from the Miocene (Janjukian) of Brown's Creek, Otway Coast, Victoria. This particular fauna was remarkable for its shallow-water and estuarine character, although, strange to say, the genus *Cyclammina*, more or less depauperated, was also abundant therein. This latter genus was only recorded between 100 and 2,900 fathoms by the *Challenger*, and was then (in 1884) "unknown in the fossil state". Subsequently, however, *Cyclammina* has been noted from moderately shallow-water fossil deposits from the ? Jurassic onwards.[2]

The average diameter of the tests of *L. simplex*, as occurring in the present washings, is ·65 mm. The diameter of that figured from the Victorian Miocene is ·55 mm.

[1] *Nonionina canariense*, d'Orbigny, 1839, Foram. Canaries, p. 128, pl. ii, figs. 33, 34; *Haplophragmium canariense*, d'Orb., sp., Brady, 1884, Rep. Chall., vol. ix, p. 310, pl. xxxv, figs. 1–5.

[2] Rec. Geol. Surv. Vict., vol. i, pt. iii, p. 229, 1904.

Genus Trochammina, Parker & Jones.

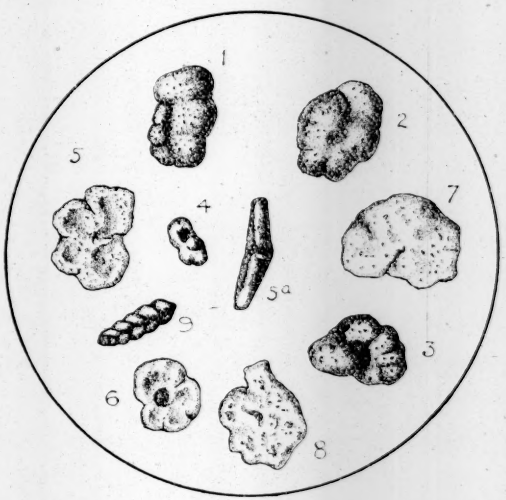
Trochammina inflata, Montagu, sp., var. *macrescens*, H. B. Brady. Figs. 5, 6.

Trochammina inflata, Montagu, sp., var. *macrescens*, Brady, 1870, Ann. Mag. Nat. Hist., ser. IV, vol. vi, p. 290, pl. xi, figs. 5*a–c*.

This variety is even more emphasized in its emaciated condition than the specimens figured by Dr. Brady from tidal river deposits of the River Blythe, Northumberland, and the River Wear, 2 miles above Sunderland, although some examples from Hengistbury Head match it almost exactly excepting in the less open umbilicus.

In the recent and brackish mud deposits, as pointed out by Brady, the tests seem to show that the emaciated appearance is due to the falling in of the thin, chitinous, and sparsely arenaceous walls, from the contraction of the protoplasm in drying.

The specific form *T. inflata* is usually found in moderately shallow marine to brackish waters round the British coast.



Foraminifera from the Eocene of Hengistbury Head, Hampshire. × 25. Drawn by F. Chapman from nature.

Figs.

1. *Haplophragmium canariense*, d'Orb., sp., var. *pauperata*, nov. Dorso-lateral aspect.
2. *H. canariense*, d'Orb., sp., var. *pauperata*, nov. Oral aspect.
3. ,, ,, ,, ,, ,, Lateral aspect.
4. ,, ,, ,, ,, ,, Micromorphic.
5. *Trochammina inflata*, Montagu, sp., var. *macrescens*, Brady. Lateral aspect. 5*a*, oral aspect.
6. *T. inflata*, Montagu, sp., var. *macrescens*, Brady. Smaller example, lateral aspect.
7. *Lituola simplex*, Chapman. Lateral aspect.
8. ,, ,, Another example, lateral aspect.
9. *Virgulina subsquamosa*, Egger. Lateral aspect.

The largest example of the Hengistbury Head series has a diameter of ·6 mm., whilst the larger of Dr. Brady's figured examples from the English tidal rivers has a diameter of ·4 mm. This variety is exceedingly common in the washings.

Fam. TEXTULARIIDÆ.

Genus Virgulina, d'Orbigny.

Virgulina subsquamosa, Egger. Fig. 9.

Virgulina subsquamosa, Egger, 1857, Neues Jahrb. für Min., etc., p. 295, pl. xii, figs. 19–21; Brady, 1884, Rep. Chall., vol. ix, p. 415, pl. ii, figs. 7–11.

Foraminiferal tests allied to this form have already occurred in the estuarine deposits (Holocene) of the Fen-land in the East of England.[1]

Only one small example of this species was found, having a length of ·423 mm.

Note on the accompanying Ironstone Bed.—A thin slice of the ironstone of the Hengistbury Head Beds was examined under the microscope, with the following result:—

The general character is that of a fine-grained ironstone composed of excessively minute granules of carbonate of iron stained with peroxide of iron. Scattered throughout the rock and occasionally occurring in nests are minute angular fragments of quartz, such as are met with in the finest river silts. A few obscure stem-like fragments are also seen embedded. Under a high power the separate granules of carbonate of iron are seen to be covered with peculiar amber and ruddy-coloured articulations, probably representing the residual peroxide of iron after the change from the condition of bog-iron ore.

Conditions of Deposition.—Some interesting facts are brought out by the foregoing occurrence of the somewhat sparse and peculiar foraminiferal fauna of the Hengistbury Head clays. The forms are all arenaceous, showing a marked absence of calcareous rocks or calciferous waters in the neighbourhood. Such a fauna is generally found in the tidal estuarine areas of great rivers close to the coast and having a partially landlocked character. Similar deposits would occur, for example, on those parts of the Essex Flats at the present day, which are occasionally flooded at especially high tides, and where, in the boggy parts, saprophytic vegetation flourishes, capable of extracting the carbonate of iron from the surrounding water. The small dimensions of these Foraminifera, the poorly developed tests with shrunken chambers, and generally starved appearance point to their being a survival of a normal deep-water terrigenous facies, which has been pushed into uncongenial surroundings; for parallel types of all the forms here enumerated are well known in many of the green and blue muds of our deeper coastal deposits.

The question here arises, how came the glauconite grains in the clay deposit if the evidence of the Foraminifera points so strongly to estuarine conditions? for glauconite seems to be, so far as known, a material which is chemically deposited under marine conditions in

[1] Brady, loc. cit., p. 415.

moderately deep, not shallow water, and generally below the actual mud-line of the coastal margin.

From geological evidence derived from other sources it is quite reasonable to assume that these glauconite grains in the clays, which by the way are worn and otherwise ill-defined, have been derived from local, disintegrated and re-sorted, moderately deep-water deposits, such as are seen in the Barton and Bracklesham Beds themselves. In the Plateau Gravels of the London Basin, by way of illustration, glauconite grains are frequent; but no one would venture to assert that these granules were actually formed in the deposit, since much of the material in places was derived from the Lower Greensand ridges to the south.

The difficulty of accounting for the presence of mollusca and sharks' teeth in the closely associated sediments may be met in this way. A slight lowering of the estuarine series would convert the area into sandy and clayey submerged marine coastal plains, on which such genera as *Corbula*, *Tellina*, *Leda*, *Area*, *Glycimeris*, *Anomia*, *Cardium*, and *Cardita* could flourish; whilst slightly deeper conditions would permit of the existence of genera like *Panopæa*. At the same time the fact of many of the mollusca found in this series being in the state of casts, shows that the sea-bottom at this period was in a state of oscillation rather than of equilibrium.

NOTICES OF MEMOIRS.

Trias and Carboniferous in the Caucasus.

Wittenburg, P. W. Recent Researches on the Trias of the Caucasus. (In Russian.) Bull. Acad. Imp. Sci. St. Petersburg, 1912, p. 433.

Robinson, W. N. Recent Researches on the Geological Structure of the Northern Caucasus in the Basins of the Rivers Bielaya and Laba. (In Russian.) Bull. Acad. Imp. Sci. St. Petersburg, 1913, p. 33.

Translated and abridged from the Russian by Felix Oswald, D.Sc., F.G.S.

THE discovery in 1907 of Upper Trias in the Kuban district of the Caucasus, which was described in the Geological Magazine (Dec. V, Vol. VI, No. 538, April, 1909, p. 171), has been considerably amplified and extended by the researches of P. W. Wittenburg, who explored the same district, viz. the upper courses of the Little Laba and Bielaya Rivers, and his results may be conveniently summarized in tabular form:—

1. *Rhætic Stage.*—(1) Typical *Avicula contorta* beds on Mt. Tkhach. (2) Lower Rhætic is represented by grey crinoidal limestone interbedded with red marly limestone containing many Brachiopods, particularly masses of *Spirigera* belonging to the typically Rhætic group of *S. oxycolpos*, Emmr., and *S. Manzavinii*, Bittn. (Kössen Beds). It is well exposed in the Kun Valley near Mt. Tkhach, and

contains *Waldheimia cubanica*, Tschern., *W.* cf. *austriaca*, Zugm., *W. Bukowski*, Bittn., *Terebratula pyriformis*, Suess, *T. turcica*, Bittn., *Rhynchonella obtusifrons*, Suess, *Spirigera cubanica*, Tschern., *Retzia superbescens*, Bittn., *Amphiclina squamula*, Bittn., *Aulacothyris* cf. *Ioharensis*, Bittn., *Mysidioptera Gremblichi*, Bittn., *Pecten subalterni-costatus*, Bittn.

2. *Noric Stage.*—The facies of the Dachstein Limestone with *Megalodus* sp. of the group *Megalodus* (*Neomegalodon*) *triqueter*, Wulfen, was found on Mt. Yatyrgvart (also in the Kuban district), but this seemed to be a somewhat isolated occurrence. The red, compact limestones usually contain a rich coral fauna (not specified) with masses of *Pseudomonotis ochotica*, var. *densistriata*, Teller, which the author considers to be synonymous with *Ps.* (*Monotis*) *salinaria*, Bronn. They dip 10° N.W. by N. and are transgressive over 3.

3. *Carnic Stage.*—Black, thinly-bedded, micaceous slates, interbedded with grey sandstones, altogether about 75 metres thick. They contain *Koninckina Telleri*, Bittn., and badly preserved *Tropites*. In the lower horizon of this series, on the eastern slopes of Mt. Tkhach, thick beds of oysters occur.

4. *Ladinian.*—(1) Red, quartzitic sandstones, interbedded with black slates and marls, dipping 20° N.N.W., containing the characteristic Wengen fossils *Daonella Lommeli*, Wissm., and *Posidonomya wengensis*, Wissm., with siliceous sponges and plant-remains in the upper part. The best sections occurred in the Sokhra Valley.

(2) Conglomerate.

(3) 'Upper contorted series,' consisting of grey calcareous flagstones, well developed to the south-east of Mt. Tkhach, and containing a Cephalopod fauna (described by Professor Karl Diener). Owing to their poor preservation the fossils could only be generically determined as follows: "*Ptychites* sp ind. of the *Megalodiscus* group; gen. ind. sp. ind. of the Pinacoceratidæ family, recalling *Norites* or *Arthaberites*, but the condition of the suture-lines would permit of its being included in *Sageceras*; *Gymnites* sp. ind. aff. *incultus*, Beyr.; *Monophyllites* sp. ind. of the group *M. Suessi*, Mojs., closely resembling *M. Pitamaha*, Diener; *Monophyllites* n.sp.; gen. ind. sp. ind. of the Ceratitidæ family, recalling *Celtites* or *Monophyllites*; this specimen in all probability represents a new species near to *Nomismoceras spiratissimum*, Holzapfel; *Balatonites* sp. ind.; *Ceratites* sp. ind. belonging to the group of *C. circumplicatus*; *Orthoceras* sp. ind."

(4) 'Lower contorted series.' Much crushed and dislocated, dark siliceous limestones, showing a prevalent dip to north-west. A bed of limestone immediately overlying this strongly contorted series contains characteristic Werfen fossils (Scythian stage), e.g., *Cœlostylina werfensis*, Witt., *Terebratula* sp., *Gervillia exporrecta*, Leps., *Pseudomonotis venetiana*, Hauer, *P.* aff. *leptopleura*, Witt. This Scythian stage is widely distributed in the north-west Caucasus, e.g. in the valley of the Bielaya River near the confluence with its tributary the Dakh River, in many places in the Sokhra Valley (another tributary of the Bielaya), on Mt. Shavshin, and on the slopes of Mt. Tkhach.

The discovery by Messrs. Wittenburg and Robinson of these Werfen Beds in the Caucasus emphasizes the importance of the Caucasian Trias as a connecting-link between the Trias of the Alps and the Himalaya, for beds of this period have long been known to occur at Julfa in the Araxes Valley (which separates Russian Armenia from Persia), containing *Meekoceras* and species of *Pseudomonotis*, which Bonnet (Bull. Soc. Géol. France, sér. 4, xii, 312) has shown to be allied to those of the *Hedenstroemia* beds of the Himalaya. The upper, unfossiliferous part of the Julfa Series, consisting of 200 metres of marly limestones overlain by 1,000 metres of black limestones and dolomites, is probably equivalent to the Middle and Upper Trias of the Caucasus.

Still more recently W. N. Robinson (op. cit.) in 1912 was able to establish the fact that the Triassic beds of the Caucasus overlie Upper Carboniferous limestones, as at Julfa. The locality is also in the basin of the Bielaya River, at Mt. Gepho on the left bank of the River Kisha (Choga), a right tributary of the Bielaya. Mt. Gepho rises to a height of 1,200 feet above the Tegen stream, which flows into the Kisha, and the natural section discloses the following downward succession :—

1. *Trias* (*Ladinian*).—(1) Grey, arenaceous flagstones with plant-remains and badly preserved fossils (not specified). Similar sandstones (dipping 70° N.E.) occur on the western spur of the Pshekish ridge. To the north-east the sandstones are dark red, very micaceous, and attain a considerable thickness.

(2) Conglomerate of small pebbles, mostly of quartz, but it varies considerably in thickness and materials; it extends nearly to the summit of Mt. Gepho and dips west. This conglomerate unconformably overlies the Carboniferous Limestone and is greatly developed along the northern slope of the Caucasus in the Kuban district. To the north-west it crops out in the Bielaya Valley, a little above Khamyshki (Alexievsk), and to the south-east as far as the Urups River and the upper course of the Zelenguk. Between the Bielaya and the Little Laba the conglomerate forms a large anticline and composes the ridges Pshekish and Bambak and the southern slope of the Mastakan ridge; it occurs also on the south-west side of the Dudugush ridge towards Mt. Oshten.

2. *Upper Carboniferous.*—(1) Grey limestones, forming rocky cliffs on both sides of the Tegen defile. They are so compact that the dip is scarcely visible, but in one place it seems to be southerly. They contain a rich Brachiopod fauna, e.g. *Entetes contractus*, Gemm., *E. carniolicus*, Schellw., *Uncinulus velifer*, Gemm., *Reticularia lineata*, Mart., *Chonetes uralica*, Möll., *Notothyris exilis*, Gemm., *Richthofenia lawrenciana*, de Kon., *Aulosteges*, *Geyerella*, with Pelecypods, Gastropods, and sponges belonging to the families Sphærospongidæ (*Heterocœlia*) and Sphærocœlidæ (*Sollasia*, *Steinmannia*).

(2) Black, argillaceous slates, forming the bed of the Tegen River, with intercalated, thinly laminated, black sandstones, dipping rather steeply to the south. They are extensively developed to the south-west, south, and south-east of Mt. Gepho, towards the main axis of the Caucasus. No fossils occur in the slates; but the interbedded

sandstones (in the Kozi Valley) contain a few undetermined Gastropods and Pelecypods.

The southerly dip of the slates is maintained over a wide area, and it is only on the south-west slope of the granite ridge Juga (Cheleps) that an anticlinal fold occurs with a steep dip to north-east. The axis of the anticline reveals crystalline schists, which form the bed of the Kisha River near Dokhmat Sheklan. This fold does not, however, extend far either to north-west or south-east. W. N. Robinson attributes the formation of this small fold to the intrusion of the granite.

The second outcrop of Upper Carboniferous was observed 2 miles S.S.W. of the confluence of the Little Laba and Urushten Rivers. The limestone is greyer than on Mt. Gepho, and forms an anticline; in its axis mica-schists and other crystalline schists are visible. To the south this Upper Carboniferous Limestone is overlain by conglomerate (probably Triassic), and higher up the Urushten River red Triassic limestones form vertical cliffs on both banks. The Upper Carboniferous Limestone contains the following fossils: *Spirifer cameratus*, Morton, *Reticularia lineata*, Mart., *Uncinulus velifer*, Gemm., *Productus gratiosus*, Waag., *P. pseudomedusa*, Tschern., Pelecypods (*Macrodon*, *Edmondia*, and *Lima*), and sponges (*Heterocœlia*).

Probably a large portion of the Palæozoic schists of the main axis of the Caucasus will be found to belong to the Carboniferous, and it may be mentioned that a crushed *Calamites* was found by Inostranzeff some years ago in the Central Caucasus to the north of the main axis.

REVIEWS.

I.—The Nature and Origin of Fiords. By Professor J. W. Gregory, D.Sc., F.R.S. 8vo; pp. xvi, 542, with 8 plates and 84 text-illustrations. London: John Murray, 1913. Price 16*s.* net.

THIS is a big book on a subject which, at first sight, seems hardly to justify such voluminous treatment; nevertheless, the author finds plenty to say. His travels have extended over wide areas of the globe, and he deals not only with the typical fiords of Norway, but with the fiords and other sea-inlets or drowned valleys, from Scotland, Greenland, and Alaska to Patagonia, Antarctica, and Australasia. Printed in bold type and well illustrated, the subject as expounded by Professor Gregory is of very great interest to geographer and geologist, and will doubtless be attractive to all travellers and students who seek to become acquainted with the origin of scenery. Apart from scenery, the author points out the influences of fiords since early times on navigation, the distribution of population, and the welfare generally of mankind.

We have been accustomed to look upon fiords, sea-lochs, and estuaries as for the most part drowned valleys excavated by rivers and in many cases also largely by glacial action, the resultant features being due to the effects of erosion on rocks of varying altitude, structure, and lithological character. Thus fiords occur among the

hard rocky mountainous regions of Norway, and equivalent sea-lochs are found in similar regions in Scotland; broader rocky channels occur in less elevated grounds in some parts of Devon and Cornwall; and water-filled valleys with still gentler slopes characterize the coastal regions of Hampshire.

No question, however, arises with regard to submergence in connexion with these inlets. The problem is the origin of the main terrestrial features, which may have been due to quite different causes; hence a grouping of the sea-inlets is desirable, more especially as the terms gulf, bay, sound, loch, and firth, as the author points out, are loosely applied to different features. He would class the sea-drowned valleys into three main types: fiords, fiards, and rias.

A fiord is described as "a long inlet which extends far inland between steep opposing walls; it usually consists of long straight reaches, which turn and receive their tributaries at sharp and regular angles; and its walls are high, as fiords are restricted to mountain regions". Furthermore, there is "a rarity of bays and a scarcity of sites for human settlements" as there is little or no margin between wall and water, except small tracts at the head, or small deltas along the sides of the fiords. They are characteristic of dissected plateaus, and "streams flow gently across the uplands until they reach the fiord-wall and then plunge down in picturesque waterfalls".

Fiards "usually have no large rivers draining into them". They "are due to a lowland area with an irregular surface of hard rocks, having been partially submerged beneath the sea. The essential difference between fiards and fiords is that fiards are characteristic of coast-lands which rise but slightly above sea-level".

Rias are ordinary river estuaries, and the author adopts the Spanish term, as such drowned valleys are well represented in North-Western Spain. The rias and fiards are alike "in having curved lines, gentle slopes, and indented shores". It is admitted, however, that it is difficult to establish sharp distinctions between fiords and other arms of the sea; fiords pass gradually into fiards and rias, the changes being due to modified conditions, such as increased submergence.

It is pointed out that most fiords occur in the more northern and southern areas of the globe, that they are in fact best developed in regions that have been subjected to glacial action. Hence it is not surprising that the excavation of the deep valleys has been attributed to glacial action.

The personal observations of Professor Gregory, fortified by a study of the writings of those who have examined special areas in detail, have led him to conclude that while "fiords are clearly valleys, of which the lower ends have been drowned by the sea", nevertheless "all the fiord-systems of the world owe their characteristic features to earth-movements, and not to glacial action". Moreover, "river-action will not produce fiords." It must be borne in mind that the deepest fiord, in Patagonia, is 4,250 feet, and that the Sogne fiord in Norway descends to nearly 4,000 feet, with bordering walls 3,000 to 4,000 feet high.

There is no doubt that many fiords were once occupied by ice, and that much shattered and weathered rocky material was then cleared

away so as to enlarge the valleys. It is contended that the plans of fiords and sea-lochs cannot be explained by glacial erosion, partly because "the course of the fiords is inconsistent with the lines of flow of the chief glaciers" or ice-sheets; but here the effects of the local glaciers may have been subsequently checked by the invasion of the more extensive sheets of ice. Fiords, however, are not limited to areas that have been glaciated, and they are not always found in regions where, if due mainly to ice-action, they should be expected.

With regard to river-action, it is pointed out that fiords are not the outlets of the main rivers, that in fact "their existence depends on the absence of large rivers, which would fill them with sediment and give them the form of ordinary valleys by wearing their walls into long, gradual slopes". Here, of course, the geological structure and physical features are largely responsible, as in the case of much of the Western Highland area, where the steep slopes and rapid drainage prevent the formation of large rivers.

The plan of the chief fiord systems of the world is stated by Professor Gregory to be essentially the same. Fiords occur in trough-shaped valleys that are arranged along a kind of angular network caused by intersecting lines of fracture. This structure was produced by the uplift of the areas to form plateaus: disturbances begun in Miocene but carried out mainly in Pliocene times. The areas of hard rocks were then more or less shattered and cleft by cracks, and subsidence took place of belts of country along the fissured grounds, the troughs or deep basins being formed by irregular movements in Pre-Glacial times. The author refers much excavation to the Pliocene period. In any case, if erosion were commenced so early, it was continued during Pleistocene times by glaciers and other agents.

Here it may be mentioned that in referring to Plymouth Sound, Mr. Clement Reid has remarked that its rocky floor shows a depression far greater than we meet with in ordinary Pleistocene valleys, and "represents not improbably a Tertiary basin".[1] Mr. J. B. Hill also, as quoted by Professor Gregory, has remarked concerning certain valleys and inlets of Southern Cornwall that "the straightness of some of them, and in other cases their parallelism, suggests that their course has frequently been determined by lines of dislocation or well-marked joints". Dr. Nansen might also have been called as a witness to the influence of earth-movements in Norway. He has stated that "the longitudinal valleys and fiords of the land surface as well as of the sea-bottom outside, indicate a system of ancient folds and perhaps faults, possibly formed simultaneously with the uplift of the northern Norwegian mountain chain, or the original subsidence of the bottom of the sea-basin outside".[2] Earlier observations, however, by Kjerulf, and the more recent researches of Dr. Sederholm and of others, receive full consideration, and the main features of the Norwegian fiords are illustrated in admirable photographs by Mr. H. W. Monckton.

[1] *Submerged Forests*, 1913, p. 84.

[2] *Norwegian N. Polar Expedition 1893-1896, Scientific Results*, vol. iv, p. 56, 1904.

Particulars are given of the fiards of Sweden, the sea-lochs and freshwater lochs of Scotland, and of drowned valleys in regions too numerous to mention. Cañons, rock-basins, and various problems of glacial erosion are also discussed, so that the author has supplied much material of profound geological interest, and much in support of his contention that fiords owe their main features to earth-movements.

II.—(1) The Mineral Kingdom. By Dr. Reinhard Brauns, Professor of Mineralogy in the University of Bonn. Translated, with additions, by L. J. Spencer, M.A., F.G.S., Mineral Department of the British Museum. 4to; in 25 parts, pp. 432, with 91 plates (73 of which are coloured) and 275 text-figures. Stuttgart, Fritz Lehmann and afterwards J. F. Schreiber; London, Williams & Norgate; 1908–12. Price 2*s.* per part and £2 16*s.* for the bound volume.

(2) The World's Minerals. By Leonard J. Spencer, M.A., F.G.S. (editor of the *Mineralogical Magazine*), Mineral Department, British Museum. 8vo; pp. 212, with 40 coloured plates and 21 diagrams. London and Edinburgh: W. & R. Chambers, Ltd., 1911. Price 3*s.* 9*d.*; American edition $2.00.

TWO works on mineralogy have recently appeared, both bearing the name of L. J. Spencer, M.A., F.G.S., upon their title-pages. For the smaller of these volumes, *The World's Minerals*, Mr. Spencer is alone responsible. But the larger work, *The Mineral Kingdom*, published in quarto form in twenty-five parts, now completed, is an English version of Dr. Reinhard Brauns's *Mineralreich*, translated, with additions, by Mr. Spencer. These two names standing together upon the title-page suffice to vouch for the excellence of the volume.

A former work by Dr. M. Bauer, *Edelsteinkunde*, 1896, also translated by Mr. Spencer, *Precious Stones*, 1904, having been now for some years in the hands of English students, has become a standard book for those who work in precious stones.

The Mineral Kingdom contains ninety-one plates, seventy-three being coloured; these give excellent representations of the various minerals. It seems almost a pity, from the artistic standpoint, to heighten the coloured figures of metallic ores by gilding and silvering, when such beautiful results are obtained by the modern photographic reproductions without gilding, although it is certainly very skilfully introduced in this work. The plates will be of great practical value, particularly to those workers whose opportunities do not enable them to consult actual specimens in public collections. In addition there are 275 figures in the text which greatly increase the value and utility of the book to any one whose work or pursuits bring them in touch with some branch of mineralogy. It is interestingly written, and the explanations are clear and easy to understand. In addition to a full description of each mineral species, the dates of their discovery, methods of identification, testing, and working, economic uses and geographical distribution, all find a place in these pages.

The classification of minerals is somewhat unusual, *The Mineral Kingdom* being divided into four great parts. The first of these

includes all metallic ores and their associates. Under this head minerals which have a special interest for the miner are described, commencing with gold. After first giving a short archæological account of the precious metal, the authors then proceed to deal with its mode of occurrence, methods of testing, geographical distribution, etc. Platinum is next dealt with, then silver, copper, mercury, lead, zinc, antimony, bismuth, arsenic, sulphur, iron, manganese, nickel, cobalt, tungsten, molybdenum, uranium, tin, and titanium. There is also a short appendix dealing with meteoric irons and stones.

Precious stones and related minerals is the next heading. This section comprises all the minerals with which the jeweller is concerned, from the diamond to 'common quartz'. These, which were fully dealt with from that standpoint in *Edelsteinkunde*, are here described from their mineralogical aspect chiefly, although methods of cutting, historical, and other points of interest are touched upon.

Part iii consists of rock-forming silicates and allied minerals. This section, apart from its purely scientific side, is one which is of interest to architects and workers in stone. Here the preparation of suitable sections for microscopic study of rock-structure is explained, and the various rock-forming minerals are described.

The last class is entitled 'mineral salts'. Several mineral substances of great commercial value are dealt with under this heading, but it also includes that group so attractive to the amateur, the fluorspars.

In *The World's Minerals* Mr. Spencer gives short descriptions of the minerals figured. The forty plates are also coloured, which is a great help to the inexperienced collector, to whom this book should prove most acceptable. The plates do not equal those in the larger work, and space of course does not allow of much more than one figure for each of the 116 mineral species described; in some cases the student would be glad of more illustrations to aid in identification. The introductory chapters are helpful and simply expressed, giving a short explanation of crystallographic systems, the physical characters of minerals, and their chemical composition and classification.

III.—Physiography.

The Realm of Nature; an Outline of Physiography. By H. R. Mill, D.Sc., LL.D. Second edition. 8vo; pp. xii, 404, with 19 coloured maps and 73 figures in text. London: Murray, 1913. Price 5*s*. net.

THE usefulness and popularity of the first edition of this book is evident from the fact that it has been reprinted no less than six times since its appearance in 1891. This edition has been thoroughly revised page by page, and can be justly recommended to the reader. The author sets forth to illustrate the principles of science by applying them to the world we live in, and to explain the methods by which our knowledge of Nature has been acquired and is being daily enlarged. The greater part of the book is occupied by an outline of the more important facts regarding the structure of the universe, the form, material, and processes of the earth, and the relations which they bear to life in its varied phases.

The headings of the chapters run as follows: Study of Nature; Substance of Nature; Energy, the Power of Nature; the Earth a Spinning Ball; the Earth a Planet; Solar System; Atmosphere, its Phenomena; Climates; Weather and Storms; Hydrosphere; Ocean Bed; Crust of Earth; Action of Water; Record of the Rocks; Continental Area; Life; Man. The maps are clearly printed and valuable, and show magnetic conditions, earthquake regions and volcanoes, isotherms, isobars, winds, rainfall, salinity of oceans, configuration of globe and coastal lines, drainage areas, evolution of continents, ocean-surface isotherms, coral reefs, rising and sinking coasts, vegetation zones, and biological regions.

It is one of those handy volumes the usefulness of which becomes daily more apparent, and the price greatly assists its recommendation. It has an index, but the worker will add to this for his own convenience such words as maelstrom, dunes, travertine, stalagmite, stalactite, metric system, zero, rigidity, atomic weight, lodestone, etc., which to publishers do not seem to be of any importance.

IV.—The Nickel Industry: with special reference to the Sudbury Region, Ontario. By A. P. Coleman, Ph.D., F.R.S. Department of Mines, Canada, No. 170, pp. vii + 206, with 14 text-figures, 63 plates, and 8 coloured maps. Ottawa, 1913.

DURING recent years the Canadian Department of Mines has issued several useful monographs on various minerals of economic importance which occur and are mined in the Dominion, and the present volume adds another to this series. The group of mines near Sudbury produces two-thirds of the world's supply of nickel, the amount for the year 1910 being 18,636 tons of metal, together with 9,630 tons of copper, of a total value of rather over one million pounds sterling. The ore here consists of an intimate mixture of pyrrhotite (magnetic pyrites), pentlandite (a sulphide of iron and nickel), and copper-pyrites, more or less intermingled with rock-forming silicates. It occurs at the base of an intrusive sheet or huge laccolite of igneous rock, and it passes imperceptibly into this. This sheet, consisting of norite in its lower portion and graduating upwards into micropegmatite, is intrusive between the crystalline rocks of the Laurentian and the sedimentary rocks of the Upper Huronian. Its outcrop forms the rim of an oval basin measuring 36 miles along the major axis and 16 miles across, and the several mines in which the nickel ore is worked are situated along the rim of this basin. We have here clear evidence of magmatic differentiation on an enormous scale; the acid rock passing downwards into basic rock, whilst at the bottom of all are the heavy metallic sulphides.

An outline of the physiography and general geology of the district and a mineralogical description of the ores is followed by an historical sketch of the mining industry, and detailed particulars relating to each of the several mines now working. Although the occurrence of nickel in this district was first recorded in 1856, it was not until 1884, when large bodies of ore were exposed in the cuttings of the

Canadian Pacific Railway, that mining operations were commenced. Curiously, however, the mines were first worked for copper (the principal nickel-producing firm still being the Canadian Copper Company), but it was soon found that the presence of nickel interfered with the extraction of the copper; and, indeed, it was not until about that time that nickel came to have any commercial value. Detailed descriptions are also given of the methods of mining, of the mechanical treatment of the ores, and of the metallurgical processes. The occurrence and treatment of nickel ores in other parts of the world, principally in New Caledonia and Norway, are also dealt with. Finally, there is a short account of the uses of nickel in coinage (though not in Canada), but particularly in nickel-steel and other alloys. No mention is, however, here made of the extensive use of nickel salts in electroplating.

V.—Professor Doelter's Mineralogy.

Handbuch der Mineralchemie. By Hofrat Prof. Dr. C. Doelter. Bd. III, i, pp. 1–160. 8vo. Steinkopf: Dresden and Leipzig. Price 6.50 marks.

THE first part of the third volume of this work deals with the oxides of titanium, zirconium, niobium, tantalum, and their compounds with silica. The quantitative separations and estimations of these oxides present many problems of grave difficulty to the chemist. The various methods in use are described and discussed by Dr. K. Peters, in addition to which there are special articles on the analysis of låvenite, eudialyte, johnstrupite, and catapleite by Dr. R. Mauzelius, and on the analysis of euxenite by Dr. G. T. Prior. Dr. R. Pribram contributes a section on the chemistry of germanium and the minerals in which it occurs.

A very interesting chemical problem is the composition of the rare mineral strüverite, which Dr. Prior has shown to be isomorphous with ilmeno-rutile: both minerals are regarded as solid solutions of tapiolite or mossite (iron tantalate and niobate) in rutile. It is suggested that the name strüverite be reserved for those members of the series in which tantalic acid preponderates over niobic acid, those richer in the latter being called ilmeno-rutile. The determination of both tantalum and niobium in the presence of large amounts of titanium thus becomes a problem of great importance: this problem has now been successfully solved by Hess and Wells in America and more recently by S. J. Johnstone in London.

Another group of minerals of great interest are the three forms of titanium dioxide; rutile, anatase, and brookite. To account for the existence of these three forms many theories have been advanced; these theories still await definite proof, for while recent analyses of rutile are fairly abundant, only two analyses of anatase and brookite appear to have been made within the last fifteen years. The brookite analysed by Rose in 1844 and said to have come from Snowdon, Wales, was doubtless from the well-known locality for that mineral near Tremadoc.

Professor Doelter himself has contributed very largely to this part

in articles on special minerals, perhaps the most important being the section dealing with zircon. Some varieties of this mineral show considerable departures from the usual formula, $Zr O_2 . Si O_2$; artificial crystals of the composition $3 Zr O_2 . 2 Si O_2$ have been prepared, and it is suggested that some such isomorphous mixtures may occur in nature. The variations in density and refractive indices of zircons, and the effect of heat, light, and radium on stones of various colours are discussed. Zircons can be divided roughly into two classes, red and brown stones on the one hand and green stones on the other. The green stones are usually less dense and have lower refractive indices than the brown ones, and at present no satisfactory explanation of these differences has been reached. As regards the colour, Professor Doelter and others have shown that the brown stones are decolorized when strongly heated, the colour returning under the influence of radium emanations, but both heat and radium are without appreciable effect on the green zircons. The inference drawn from these facts is that the brown colour is due to a radio-active constituent of the zircons, while the green stones owe their colour to some more stable substance.

VI.—Geology in the Congo.

Annales de la Société géologique de Belgique. Publications relatives au Congo Belge, 1912–13, pp. 75–125.

THE Geological Society of Belgium are to be congratulated on the work which their members are doing in the Congo, and which they are now publishing in an appendix to the annals of the Society. The second part of this special publication contains details of a boring passing through 80 metres of the Lualaba Series, observations on the lower part of the Lubilache Beds, and a second series of M. Buttgenbach's contributions to the petrology of the district.

M. Mercenier, working in the neighbourhood of Albertville on the west of Lake Tanganyika, has traced a series of great faults running approximately parallel to the Tanganyika depression. M. Cornet has previously demonstrated the existence farther to the west of another great depression some 200 kilometres in length, which he has called the Upemba "graben". In a preliminary note by M. Delhaye on the Katanga district we find evidence of yet another great series of trough-faults causing the depression of the Lufira River. M. Mathieu, in a paper on the hot springs of Lower Katanga, shows that the distribution and characters of these springs bear a relation to the areas of depression. He records the temperature and mineral composition of these springs throughout the area, and shows that these characters are closely related to their distribution. Thus the hot springs of the Tanganyika depression have a temperature of 40–55° F., are highly charged with chlorides, sulphates, and soda, and contain relatively little carbonate: those of the Upemba depression, on the other hand, have a temperature of 70–100° F., are not highly mineralized, and carbonates preponderate over chlorides and sulphates. Springs of the first group appear to be connected with eruptive rocks; those of the second group occur mainly at contacts of the quartzites with granitic rocks.

VII.—Brief Notices.

1. On the Skeleton of *Ornithodesmus latidens*: an Ornithosaur from the Wealden Shales of Atherfield, Isle of Wight. By R. W. Hooley. Quart. Journ. Geol. Soc., vol. lxix, pp. 372–422, pls. xxxvi–xl, 1913.

In this important paper Mr. Hooley gives a very complete description of a new species of Pterodactyl, founded mainly on a remarkable specimen in which the bones are most perfectly preserved and quite uncrushed. The author was able to remove the very hard matrix to such an extent that he could find by actual trial the natural motions of the bones on one another, and in this way to study the mechanics of the reptile's wings. The type is a very remarkable one and of great interest, because it represents an extremely large animal, spread of wing about 5 metres, belonging to quite a different group from the other well-known large types, the toothless *Ornithostoma* of the Kansas Chalk. The paper concludes with a discussion of some points in the structure of Pterodactyls and of their classification in the light of this new type.

2. Rekonstruktionen des Flugsauriers, *Rhamphorhynchus Gemmingi*, H. v. M. By Ernst Stromen, of Munich. Neues Jahrbuch für Min. Geol. u. Pal., January, 1913, Bd. ii, S. 49–68, Taf. iii–v.

An important paper, dealing with many points in the osteology of Pterodactyls, illustrated by a beautiful drawing of a restoration of the skeleton, and photographs of a remarkable life-size model of the skeleton from three aspects, which give a much better idea of the build of a long-tailed Ornithosaur than has previously been possible.

3. On some New Genera and Species of Dicynodont Reptiles, with Notes on a few others. By R. Broom. Bull. Amer. Mus. Nat. Hist., vol. xxxii, art. xxvi, pp. 441–57.

A description of three new genera and thirteen new species of Dicynodont reptiles. The specific and generic characters are mostly drawn from the features of the top of the skull in the pineal region, particularly from the relations of the pre-parietal, which are illustrated by clear figures.

4. Note on *Equus capensis*, Broom. Bull. Amer. Mus. Nat. Hist., vol. xxxii, art. xxv, pp. 437–9.

A description of upper premolar (pm.^{4}) of the large *E. capensis*, which is found associated with the extinct *Bos baini*, *Connochætes antiquus*, *Colus venteræ*, and human implements.

5. On Evidence of a Mammal-like Dental Succession in the Cynodont Reptiles. By R. Broom. Bull. Amer. Mus. Nat. Hist., vol. xxxii, art. xxviii, pp. 465–8.

Dr. Broom describes a specimen which appears to give satisfactory evidence of the replacement of canines, incisors, and milk molars in *Diademodon*, a discovery of very great importance, as hitherto, although examples of Therocephalia, Gorgonopsids, and Cynodonts showing replacements of the canine have been fairly common, and

specimens showing replacements of the incisors known, none have shown any replacement of cheek-teeth, a fact which has told somewhat against the relation of these types to mammals. It now seems probable that the group will show us all the stages, from the indefinite replacement of teeth in the ordinary reptilia to a very definite replacement similar to that occurring in mammals. The specimen is perhaps not absolutely conclusive, but affords very considerable reasons for believing that Dr. Broom's interpretation is correct.

6. On the Origin of the Cheiropterygium. By R. Broom. Bull. Amer. Mus. Nat. Hist., vol. xxxii, art. xxvii, pp. 459–64.

A description of the well-known fin of *Sauripterus taylori*, and the suggestion that the Tetrapod limb may have been derived from such a fin by the development of some of the pre-axial skeletal elements and the loss of the post-axial, which continued to support the fin during the change.

7. The Skull Elements of the Permian Tetrapoda in the American Museum of Natural History, New York. By F. v. Huene, Tübingen.

In this large paper the author gives short descriptions and figures of many of the types of reptiles found in the 'Permian' of Texas. This paper is important in that it contains the views and criticisms of a distinguished and independent author on many of the disputed facts of structure of these very interesting forms. Dr. v. Huene not only adds to our knowledge by determining many new sutures, but also by redetermining some of the bones figured by Case. The author adds some interesting discussion on morphological points and on taxonomy.

8. The Tegelen Bear.—Mr. E. T. Newton has described under the name of *Ursus etruscus* (= *U. arvernensis*) a number of teeth from the Pliocene clay of Tegelen-sur-Meuse (Geological Proceedings for Netherlands and Colonies, 's Gravenhage, 1913). He remarks that "At present *U. etruscus* is only known from Pliocene deposits of Europe; but there are indications of somewhat similar fossil forms occurring in India and China, and it may well be that from these Pliocene species the modern Black Bears are descended which to-day are found widely distributed in America and Asia".

9. Mr. Chester G. Gilbert and Mr. Joseph E. Pogue contribute to the Proceedings of the United States National Museum, vol. xlv, 1913, a paper on "The Mount Lyell Copper District of Tasmania", in which they gave a succinct account of the geology and mode of working the famous copper-mines. The paper, which is the outcome of a study of a representative collection of rocks received in 1910 by the museum from Mr. Robert Slicht, manager of the Mount Lyell Mining and Railway Co., is largely based upon Professor J. W. Gregory's well-known memoir.

10. In the Bulletin de la Société Belge de Géologie, vol. xxvii, 1913, M. A. Ledoux gives the results of an elaborate study of quartz crystals from Belgium, and records altogether eighty-one forms. Twins are very common, and, indeed, etching figures show that

simple individuals are rare. Groups of crossed crystals are often met with which are not true twins. The various occurrences—in eruptive rocks, metalliferous veins, quartz veins, and sedimentary rocks—are described in detail. The paper is amply illustrated.

11. Fluting and Pitting of Granites.—An interesting and well-illustrated article on this subject, by Mr. J. C. Branner, has been published by the American Philosophical Society (Proc. lii, April, 1913). The fluting of granites and other crystalline rocks appears to be confined to tropical and possibly sub-tropical countries. Striking examples are seen near Quixadá, in Ceará State, Brazil, mostly in massive coarse-grained gneissoid granodiorites. The furrows start at or near the summit of the exposed rock, and run straight down the rock-slopes by the shortest possible routes. Some reach a depth of nearly 2 metres measured at right angles to the general surface of the rock-masses. In the same region the fluted rocks have been hollowed into "great rounded caldron-like pits, some of which are associated directly or indirectly with the fluting". These pits seldom exceed 2 metres in depth and their diameter is about 2 metres. In certain cases they occur in a nearly vertical row, connected by a furrow, and having the appearance of a great irregular staircase mounting the hill. The fluting seems to occur only on steep slopes, with an angle of 45° or more, and it is caused by the rainfall, small in amount, that acts in part chemically, in part mechanically. The pits are formed by the disintegration and dissolution of minerals.

REPORTS AND PROCEEDINGS.

I.—Geological Society of London.

November 5, 1913.—Dr. Aubrey Strahan, F.R.S., President, in the Chair.

The following communication was read:—

"Geological Sections through the Andes of Peru and Bolivia." By James Archibald Douglas, M.A., B.Sc., F.G.S.

This paper deals with the geological structure of the South American Andes, as illustrated by a horizontal section drawn from the port of Arica in the extreme north of Chile (formerly Peruvian territory) across the mountain-ranges or 'Cordilleras' to the forested region of the Amazon slopes, in the district known as the Bolivian 'Yungas', following the route of the new Arica–La Paz railway, which was under course of construction at the time of the author's visit.

It is the partial result of two years' geological exploration in Peru, undertaken on behalf of Mr. W. E. Balston, F.G.S., for the Oxford University Museum. After a description of the general physiography of the Peruvian Andes, the topographical features of the country traversed by the railway are discussed in some detail.

Its geological structure is then described under three headings: (1) The Mesozoic sediments of the coastal region with their contemporaneous igneous rocks, the intruded core of granodiorite, and the

overlying recent volcanic rocks of the Western Cordillera. (2) The volcanic rocks of the Mauri River, the Mesozoic and Palæozoic sediments of the 'Altaplanicie' and the Titicaca district; the line of dioritic intrusions, and the Pleistocene gravels of the Desaguadero River. (3) The Palæozoic rocks and granitic core of the Eastern Cordillera and the Amazon slopes.

(1) The Mesozoic stratified rocks are well exposed in the 'Morro de Arica', where fossils occur which indicate an Upper Jurassic (Callovian) age. They are interbedded with thick sheets of basic enstatite-andesite, showing well-marked 'pillow'-structure; this rock is remarkably fresh, and free from albitization.

Similar stratified rocks are traced up the Llutah and Palca river-valleys. In the former they are penetrated by a thick intrusion of quartz-hypersthene-norite, which, it is suggested, is the plutonic equivalent of the pillow-lava of the coast.

The erosion of the river-valleys that has brought to light the Jurassic sediments has also laid bare the underlying plutonic mass of granodiorite, which may be regarded as the deep-seated core of the Western 'Cordillera'. This plutonic mass appears to have been intruded in the form of a batholite in post-Cretaceous times.

The Western Cordillera is essentially a volcanic range, formed of numerous more or less isolated, snow-capped, dormant, and extinct volcanoes, attaining heights of 19,000 to 20,000 feet. The enormous amount of volcanic material emitted from these cones has almost completely concealed the underlying rocks.

The lavas can be resolved into three main groups, characterized by their dominant ferromagnesian mineral, succeeding one another in age according to a law of increasing basicity: (*a*) acid rhyolites and tuffs with biotite; (*b*) trachytes and trachy-andesites with hornblende, typically developed in the district of Mount Taapaca; (*c*) andesites and basalts with pyroxenes, forming the cones of Mounts Tacora and Chupiquiña.

(2) The western part of the high-level Bolivian plateau, or 'Altaplanicie', is almost entirely covered by vast horizontal sheets of volcanic ash, tuff, and pumiceous lava, described as the Mauri Volcanic Series. These rocks have often the appearance of 'trass', and it is suggested that they have been formed in large part as subaqueous deposits. The occurrence in an interbedded layer of gravel of a fragment of a jaw of '*Nesodon*', almost identical in appearance with specimens from the Miocene beds of Santa Cruz, affords the only clue for an estimation of their age. They are overlain on the east by gravel deposits of the Desaguadero River, the highest terrace of which was found to contain remains of *Mastodon*, *Megatherium*, *Scelidotherium*, and other Pleistocene vertebrates.

From beneath these superficial deposits crops out a series of unfossiliferous red and chocolate-coloured sandstones and conglomerates. After comparison with other districts on the north, these are divided into two groups—a younger gypsiferous sandstone and marl series of Cretaceous age, broken through by a line of dioritic intrusions and resting with pseudoconformity on an older Permo-Carboniferous group. The latter ends abruptly along a fault-line against vertical

shales and quartzites, containing a few characteristic Lower Devonian fossils. These Devonian beds, though much concealed by alluvial plains, form the basement of the eastern part of the 'Altaplanicie'.

The Carboniferous formation is nowhere exposed along the line of section, but an account is given of its development in the region of Lake Titicaca, where the limestones contain an Upper Carboniferous or Permo-Carboniferous marine fauna.

A short discussion is entered into on the theory of the recent elevation of the Andes and the origin of Lake Titicaca.

(3) The Eastern Cordillera rises to heights of over 22,000 feet, being composed chiefly of steeply dipping Devonian slates and quartzites, though many of the unfossiliferous black slates and greywackes of the eastern slopes most probably may be referred to the Silurian, or even to an older formation. Outcrops of granite are of rare occurrence along the line of section, although there is reason to suppose that this rock forms the core of most of the high peaks. As marine Lower Carboniferous and Upper Devonian rocks are absent from this district, it is suggested that the granitic core was intruded during a period of land-elevation at this time.

II.—Zoological Society of London.

October 28, 1913.—Professor E. A. Minchin, M.A., F.R.S., F.Z.S., Vice-President, in the Chair.

1. Dr. F. A. Bather, M.A., F.R.S., F.Z.S., read a paper entitled "The Fossil Crinoids referred to *Hypocrinus*, Beyrich". The two specimens of *Hypocrinus schneideri*, Beyr., described by Beyrich and Rothpletz respectively, are redescribed and refigured. The structure of the genus is shown to agree with that of the Devonian family Gasterocomidæ, the content of which is discussed; but it is suggested that in this case and in that of '*Lecythiocrinus*' *adamsi* the distinctive features may have been independently acquired.

The holotype of *Hypocrinus piriformis*, Rothpletz, is redescribed and refigured, and proved to be no *Hypocrinus*. It is thought to be a highly modified descendant of the Taxocrinidæ, by way of such a genus as *Cydonocrinus*. The left posterior radial appears to have borne a large arm, but the other arms are more or less atrophied, and the right posterior radial has almost disappeared.

2. A paper on "*Batrachiderpeton lineatum*, Hancock & Atthey, a Coal-measure Stegocephalian", communicated by Professor J. P. Hill, D.Sc., F.R.S., F.Z.S., was read by Mr. D. M. S. Watson, M.Sc. It contained the description of the skull, lower jaw, and pectoral girdle of this species, based on a series of specimens in the Newcastle Museum, derived from the Low Main Seam of Newsham Colliery.

3. A paper, communicated by Dr. C. W. Andrews, F.R.S., F.Z.S., was received from Mr. R. W. Palmer, M.Sc., entitled "The Brain and Brain-case of a Fossil Ungulate of the genus *Anoplotherium*", in which a cranium from the Phosphorites of Quercy, together with an exceptionally perfect and well-marked brain-cast obtained from it, were described from material in the British Museum collections.

OBITUARY.

HENRY FRANKLIN PARSONS, M.D., F.G.S.

BORN FEBRUARY 27, 1846. DIED OCTOBER 29, 1913.

WE much regret to record the death, at the age of 67, of Dr. Franklin Parsons, F.G.S., a medical officer who was distinguished for his extensive knowledge and wide experience of sanitary science, who was an enthusiastic worker in geology, and an expert botanist.

He was born at Beckington, a village about 3 miles north-east of Frome in Somerset, and was the eldest son of Joshua Parsons, a surgeon, who took much interest in the natural history of the district. The geological features are extremely varied, as within a walking distance of Beckington there can be studied the Old Red Sandstone and Carboniferous rocks, the Trias, Lias, most of the Oolitic rocks, and Upper Cretaceous strata. After education in private schools Franklin Parsons proceeded to St. Mary's Hospital, and subsequently took high honours in medical subjects at the University of London, with the degree of M.D. in 1870. From 1867–73 he was engaged in medical practice with his father at Beckington, and devoted most of his leisure to the study of geology and botany. Some of his observations were communicated later on to the Somersetshire Archæological and Natural History Society in a paper on "The Flora of East Somerset" (1875), wherein he pointed out the relations between the geology and the distribution of the plants, and in another paper on the "Geology of the District around Bruton" (1879).

In 1874 Dr. Parsons was appointed Medical Officer of Health for the combined districts of Goole and Selby, in Yorkshire. Here he turned his attention to local natural history, to the warp of the Humber and its diatoms, the results being given to the Geological Society of the West Riding in papers on "The Maritime Plants and Tidal Rivers" (1876), and on "The Alluvial Strata of the Lower Ouse Valley" (1878). To the same Society he also communicated a paper on "The Trias of the Southern Part of the Vale of York" (1879).

Dr. Parsons was married in 1879 to the daughter of the late John Wells, J.P., of Booth Ferry House, Yorkshire, and the same year was appointed a Medical Inspector on the Local Government Board. In this department he was frequently engaged on sanitary questions in which his knowledge of geology was of great practical service, as in connexion with sites for cemeteries and sewage-farms, with water-supply, pollution, and sundry epidemics. He prepared a "Memorandum on the Sanitary Requirements of Cemeteries", which was issued by the Local Government Board in 1880 and revised in 1906. In 1892 he became Assistant Medical Officer, being second in command on the Medical Staff of the Board, and this post, which included that of Inspector for General Sanitary Purposes, he held until his retirement early in 1911. Among his many official publications it will be appropriate here to mention his "Report on Geological Considerations in relation to Public Health and Sanitary Administration" (30th Ann. Rep. Loc. Gov. Board for 1900–1, 1902, p. 258). When President of the Epidemiological Society he

delivered addresses on "Half a Century of Sanitary Progress and its Results" and "On the Comparative Mortality of English Districts". As remarked in the *Lancet* (November 8, 1913, p. 1356), "he probably influenced the sanitary development of this country more than anyone else." He was Examiner in Hygiene and State Medicine for the University of London, and for the diploma of Public Health at Cambridge. He likewise served on various departmental committees, including the annual Consultatory Committee on the Geological Survey, under the Board of Education. To the Geological Survey he rendered much assistance in the matter of water supply, and his name appears on the title-page of memoirs dealing with the wells and borings in Lincolnshire, Suffolk, Kent, and Sussex (supplement). Dr. Parsons became a Fellow of the Geological Society in 1877, and a member of the Geologists' Association in 1911. He was an active member of the Croydon Natural History and Scientific Society, usually exhibiting at the meetings of the Geological Section some of the fossils which he had collected. As President for the year 1912 he delivered (on January 21 of this year) an address on "Plant Growth and Soil Conditions". H. B. W.

PROFESSOR DR. ANTON FRITSCH.

We regret to record the death of our old friend Professor Dr. Anton Fritsch, Director of the Royal Bohemian Natural History Museum, Prague, which took place on the morning of November 15. Dr. Fritsch had attained his 82nd year, and we hope to give some account of his long scientific career next month.

MISCELLANEOUS.

Appointment of New Director to the Geological Survey and Museum.—The President of the Board of Education has appointed Dr. Aubrey Strahan, F.R.S., to be Director of the Geological Survey of Great Britain and Museum of Practical Geology, in succession to Dr. J. J. H. Teall, F.R.S., who will retire from the post on January 5 next. Dr. Strahan, who was born in 1852, was educated at Eton and St. John's College, Cambridge. He was elected a Fellow of the Royal Society in 1903, and is President of the Geological Society. He is the Assistant Director of the Geological Survey of England and Wales.

Dr. Teall, who was born on January 5, 1849, has been Director of the Geological Survey and Museum since 1901. He is the author of *British Petrography, a Description of the Rocks of the British Isles*, 1888.

Kent Coal-field.—Dr. Malcolm Burr has tabulated and printed in the *Colliery Guardian* for October 10, 1913, the available information as to the strata revealed by the borings at Tilmanstone, Guildford, Oxney, Maydensole, Ripple, Barfrestone, Goodnestone, Trapham, Woodnesborough, Stodmarsh, Walmestone, and Mattice Hill. We say 'available' because, as the author notes, many of the bores being made by chisel there were no 'cores' of the softer beds. Detailed reports are promised later by Mr. Arber and Mr. H. Bolton.

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